Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MARCH, 1951

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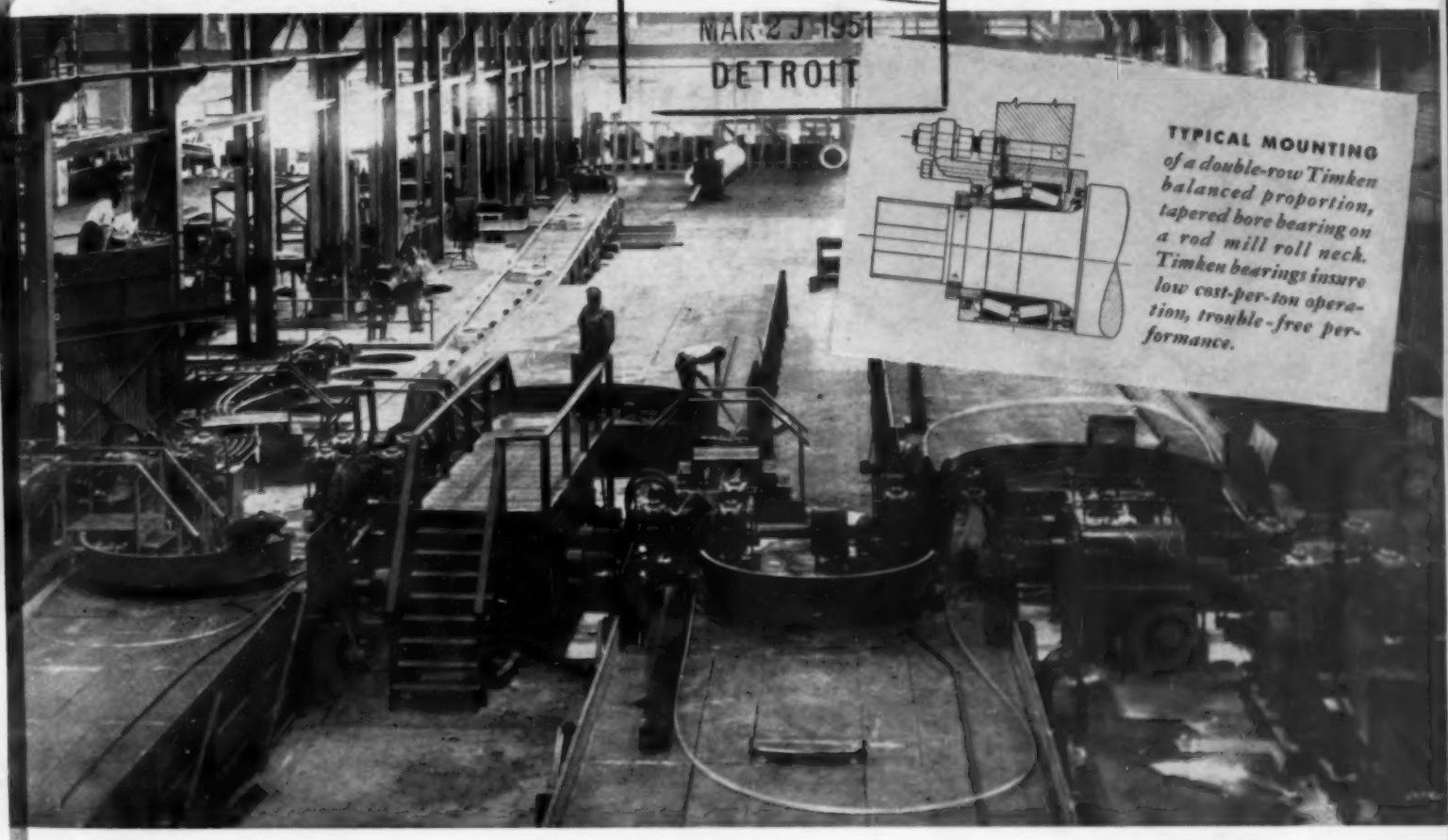


TYPICAL MOUNTING *of a double-row Timken balanced proportion, tapered bore bearing on a rod mill roll neck. Timken bearings insure low cost-per-ton operation, trouble-free performance.*

How TIMKEN® bearings put the squeeze on cost-per-ton

WITH the work rolls of this aluminum rod mill, built by United Engineering and Foundry Co., mounted on Timken® roll neck bearings, cost-per-ton of rolling aluminum can be held to a minimum. This mill, at Kaiser Aluminum and Chemical Corporation's Newark, Ohio, plant, will also get long-run trouble-free production . . . higher output . . . and a consistently fine product.

Because of balanced proportion design, Timken bearings give greater mill rigidity. Higher rolling speeds are possible because Timken bearings operate freely, frictionlessly.

Timken bearings permit the use of simple, economical grease lubrication, eliminating the use of complicated and costly systems. Rolls can be changed faster, more easily.

And Timken bearings are made of the finest material ever developed for tapered roller bearings—Timken fine alloy steel. Rollers and races are case-hardened to give a wear-resistant outer surface and a tough, shock-resistant inner core. Line contact between rollers and races means extra load carrying capacity.

You can get *all* these advantages in new or existing equipment by specifying Timken balanced proportion roll neck bearings for your mills. Consult our roll neck bearing specialists for full information. Write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN

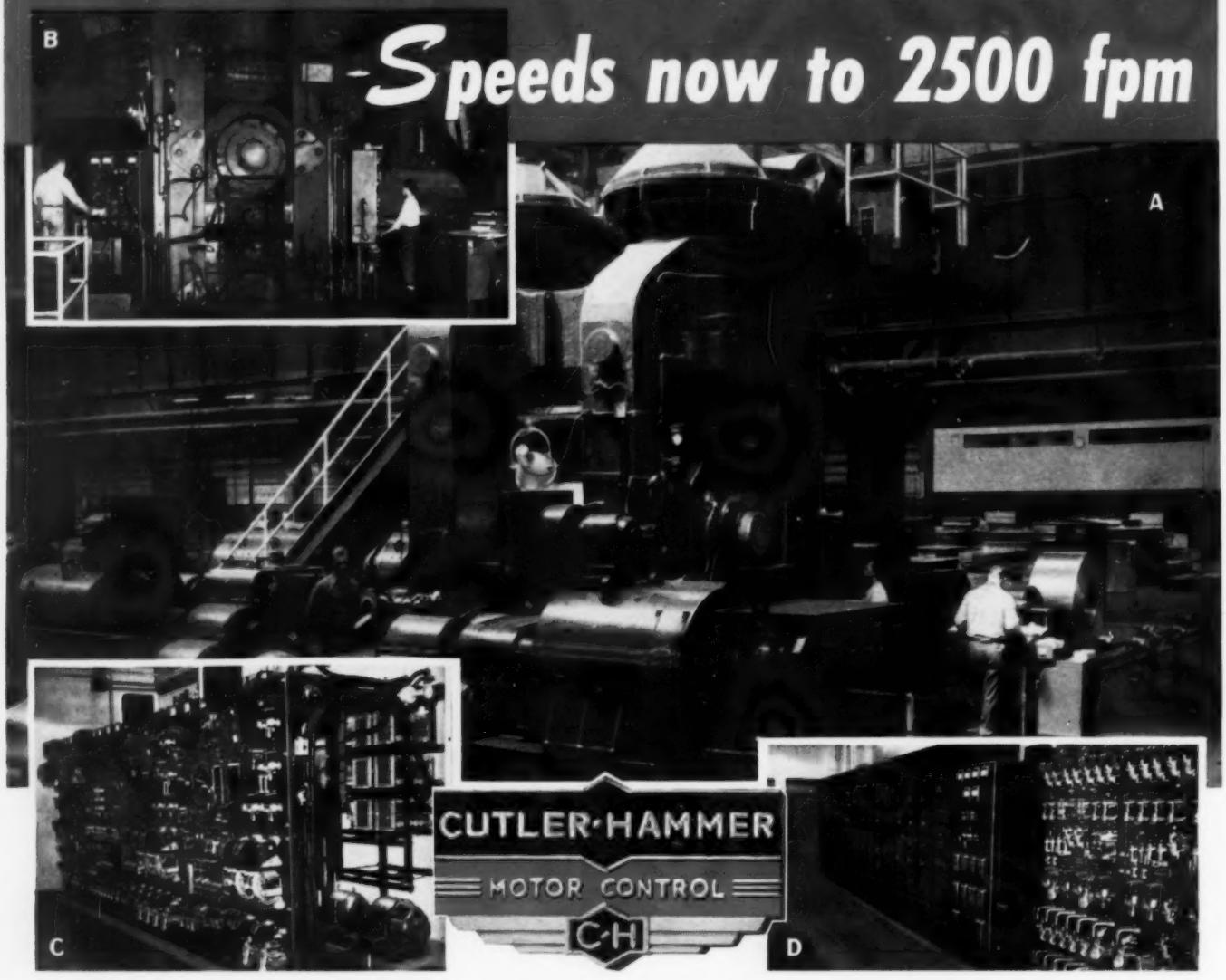
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▱ BEARING TAKES RADIAL ◎ AND THRUST ←◎→ LOADS OR ANY COMBINATION ←◎→

Carnegie-Illinois Temper Pass Mill REBUILT

--Speeds now to 2500 fpm



Behind this feat is the engineering know-how of Cutler-Hammer, Elliott, and Reliance

Part of a modernization program instituted at the Carnegie-Illinois Irvin Works was the complete rebuilding of the No. 3 sheet temper pass mill. This now-modern mill processes coils of steel sheet up to 50 inches in width, 72 inches in diameter, and 50,000 lbs. in weight, at a speed range of 250 to 2500 feet per minute, with 3750 fpm a possibility in the future. Control of this mill is such that the operator can maintain tension at any degree—the requirement most vital to uniform sheet texture and quality—during "stall", acceleration, normal operation at any selected speed and especially during deceleration. Cutler-Hammer furnished the control engineering behind this outstanding achievement . . . as has been so often the case in events that have written steel mill history . . . CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

Ⓐ 2500 fpm is the speed of the strip passing through this new mill.

Ⓑ Two Cutler-Hammer Control stands provide these operators with control of all operations of the mill.

Ⓒ Cutler-Hammer Control Panel for D.C. Main Mill Drive.

Ⓓ Cutler-Hammer D.C. Auxiliary Control and A.C. Unitrol cubicles.

Features of the New Temper Pass Mill Drive

All operations performed from operator's cabinet at each end of mill. Threading strip through mill done in minimum time. Strip tension between mill and reels then regulated to desired degree by means of Reliance VSA current regulating exciters. By proper adjustment of compensation for IR drop, friction, windage, and strip speed, tension may be held constant or tapered as required for uniform quality of processed strip. Change in reel motor current and thus tension, is translated to VSA regulators which immediately modify reel motor fields to re-establish the tension. Sudden transient requirements of wider current modification are also translated to VSA voltage regulators. Reel generators immediately respond to help re-establish desired current. Required change in current and torque when accelerating and decelerating is measured by a WR^2 compensating device which responds to rate of change in mill speed and thus insures proper compensation with any rate of acceleration.

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AETNA-STANDARD makes the mills . . .

which make CONTINUOUS BUTT WELD PIPE

aetna-standard

THE AETNA-STANDARD ENGINEERING COMPANY . YOUNGSTOWN, OHIO

Plants in Warren, Ohio . Ellwood City, Pennsylvania

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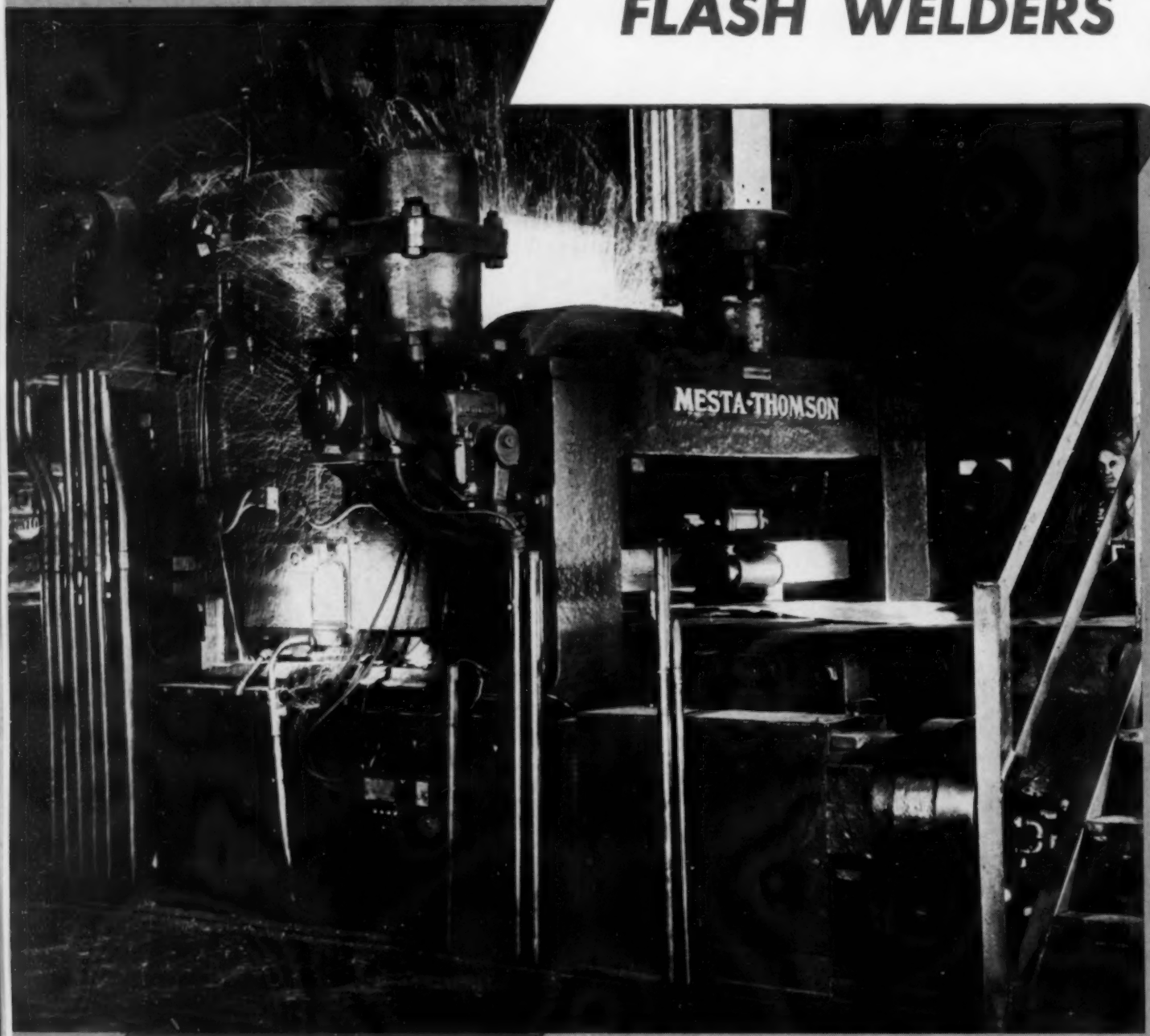
Designers and Builders to the Ferrous, Non-Ferrous, Leather and Rubber Industries

Increase

Cold Mill Production with . . . MESTA-THOMSON FLASH WELDERS



Mesta-Thomson Flash Welder installed in a Mesta High-Speed Continuous Pickling Line

MESTA MACHINE COMPANY
PITTSBURGH, PA.
Designers and Builders of Complete Steel Plants

You get practical help on lubrication and maintenance problems

WHEN THE GULF LUBRICATION ENGINEER IS 'IN THE PICTURE'

One of the best sources of help on any steel mill problem that involves lubricants, lubrication, or related maintenance problems is a trained Gulf Lubrication Engineer.

Gulf Lubrication Engineers are experts in petroleum technology—they are familiar with refining processes, properties, and the past performance records of various types of lubricants. They completely understand the effect of different operating conditions on lubricants. And, just as important, they know the lubrication requirements of all types of steel mill equipment. The application of this knowledge and experience to each individual problem helps reduce maintenance costs and improve performance of every unit.

To get the benefits of this expert engineering service for your equipment, call in a Gulf Lubrication Engineer today. Write, wire, or phone your nearest Gulf office. Gulf Oil Corporation · Gulf Refining Company, Gulf Building, Pittsburgh 30, Pennsylvania.

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1901 GULF 1951
PETROLEUM AND ITS PRODUCTS

This **HOMESTEAD VALVE** opens or closes

instantly . . . every time . . . any time

IT'S STICK-PROOF

BECAUSE IT'S LEVER-SEALD

HOMESTEAD LEVER-SEALD QUARTER-TURN VALVES have been first choice for more than 16 years in services where extremes of temperature or pressure, or corrosive fluids, cause ordinary valves to "stick" or "seize".

They are "stick-proof" because built into each valve is a powerful lever-and-screw device that prevents sticking and assures positive action at all times under all conditions.

They operate faster too, than screw-stem type valves . . . 16 to 28 times faster. And the quarter-turn principle makes them ideal for installation in restricted areas, next to walls, floors, ceilings, congested piping and other obstructions where other types of valves could not be used. Next time you have a sticking or damaged valve replace it with a Homestead LEVER-SEALD Quarter-Turn Valve. You'll never be satisfied with ordinary valves again.

Homestead Lever-Seald Quarter-Turn Valves are available in metals and alloys to suit your needs in sizes from 1½" to 10" for pressures from vacuum to 1500 lbs.

- **Instant Stick-Proof Operation.**
- **Quarter-turn fully opens or closes.**
- **Seating surfaces always protected. Corrosion practically eliminated.**
- **Unobstructed straight-line fluid flow.**
- **All moving parts protected from effects of service conditions and weather.**

For full particulars send for "Valve Reference Book No. 39-3." Write today.

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"Serving Since 1892"

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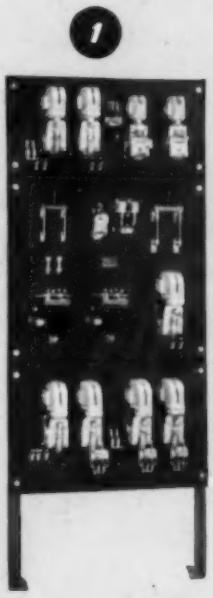
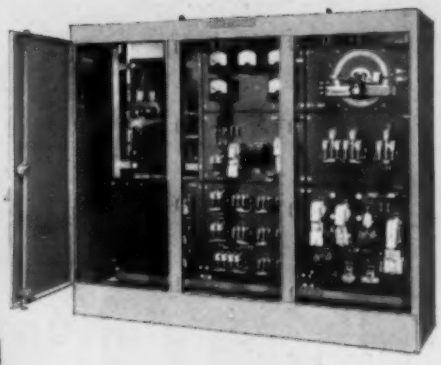
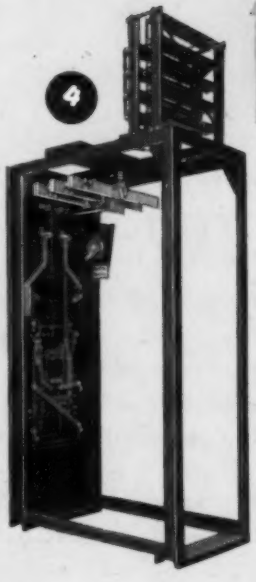
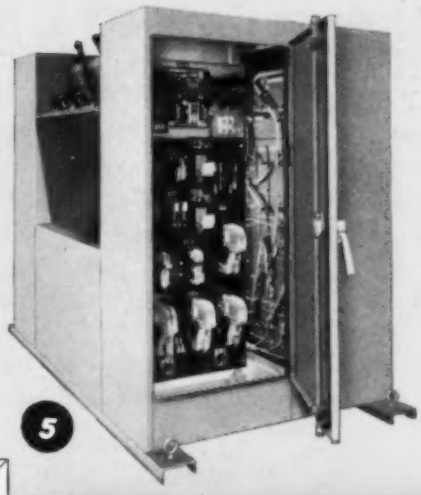
STANDARD AND SPECIAL
HEAVY-DUTY D.C. MILL AUXILIARY & CRANE CONTROL









1 Dynamic Lowering Control Panel for cab-operated crane hoist. New network system gives surer hook control with only nine contactors. ***STANDARD***

2 Steel Mill Auxiliary Controller for reversing, dynamic braking service. Features include automatic acceleration by pneumatic timers, mill type overload relays, heavy duty control relays and contactors. ***STANDARD***

3 Variable Voltage Controller for continuous strip process line. With motor-operated field rheostat. ***SPECIAL***

4 Sectionalized Mill Control Panel with frame, line bussing, resistor bank. ***SPECIAL***

5 Benchboard and Control Cubicle for leveler and shear. Combination A.C. and D.C. control. ***SPECIAL***

Do you have a Control Problem?

Trained Field Engineers are at your service through Square D offices in more than 50 principal cities.

Contact the nearest Square D Field Office or write direct to the Square D Company, 4041 N. Richards Street, Milwaukee 12, Wis.

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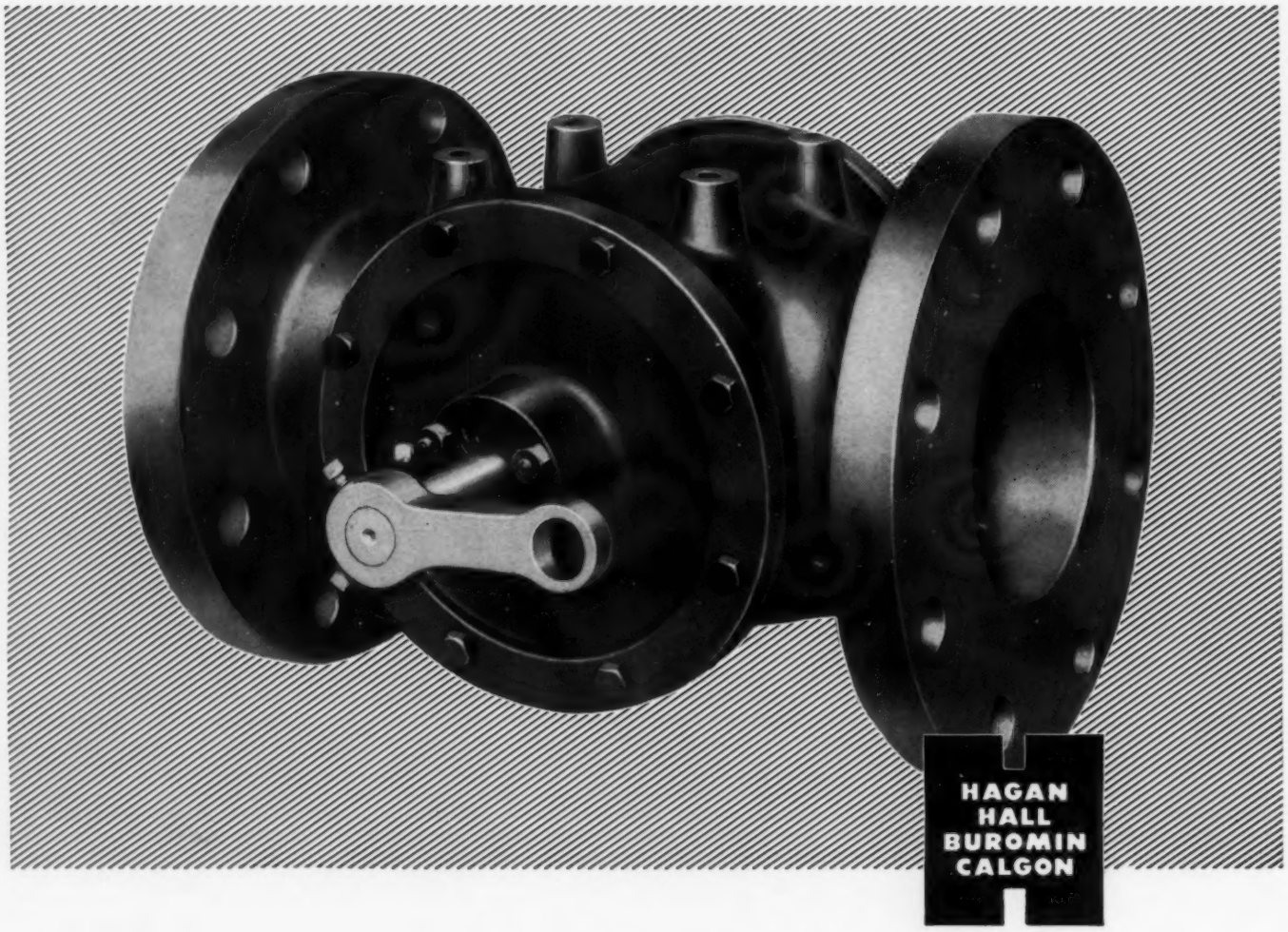
The Hagan V-Port Butterfly Valve



gives smooth, accurate regulation over the entire range of operation

Accurate proportioning of fuel and air is essential in the modern furnace, where heat input may vary over a turn-down range of 10 to 1. The need is particularly great at the low rates because at this time steel is up to temperature and most sensitive to furnace atmosphere.

At a minimum flow, the differential across regulating valves is usually the greatest. Losses across the measuring orifice, duct work and burner decrease, so that loss across the regulating butterfly must increase by a corresponding amount.

In the Hagan V-Port Butterfly Valve all of these factors are taken into account in port design, and smooth, accurate regulation is secured over the entire range of operation.

The shape of the ports in this valve is such that full advantage is taken of the inherent sensitivity and accuracy of regulating equipment.

Hagan V-Port Butterfly Valves are made in standard pipe sizes. They are ruggedly built and accurately machined. Our engineers will be glad to give you full information.

Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

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BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

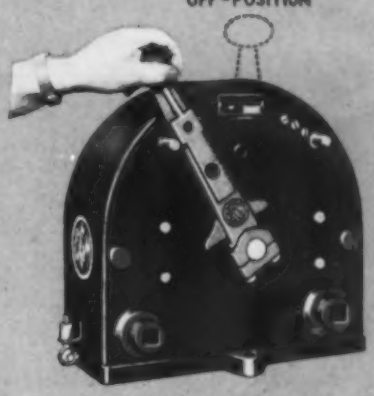
HEAVY LOADS SPOTTED QUICKLY, SAFELY

Here's Where EC&M CONTROL Gives Unexcelled Results

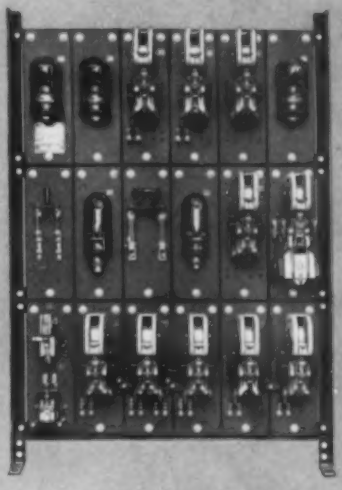
The EC&M Wright Dynamic Lowering Circuit Controller for crane-hoists is well known for its ability to permit accurate, short movements when spotting a load. The operator has complete control of all lowering speed-points. In setting the cope with this 125-ton crane, quick response through fast brake release enables the operator to close the mold carefully—with a minimum number of movements which maintenance men recognize as a contributing factor to reduced up-keep. The Wright Circuit is safe—specify EC&M Crane Control.

WRITE FOR BULLETIN 921

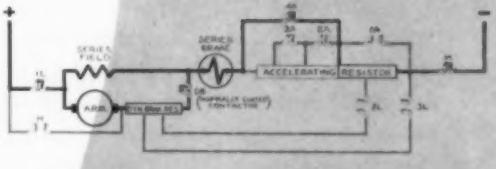
Photo—Courtesy, Cleveland Crane & Engineering



Speed-control Master Switches have short throw—narrow width—and are convenient for the operator to use.



The Wright Dynamic Lowering Circuit Controller (with protection) for crane-hoists.



First point lowering connections put all the current from the line through the brake for fast release.

THE ELECTRIC CONTROLLER & MFG. CO.
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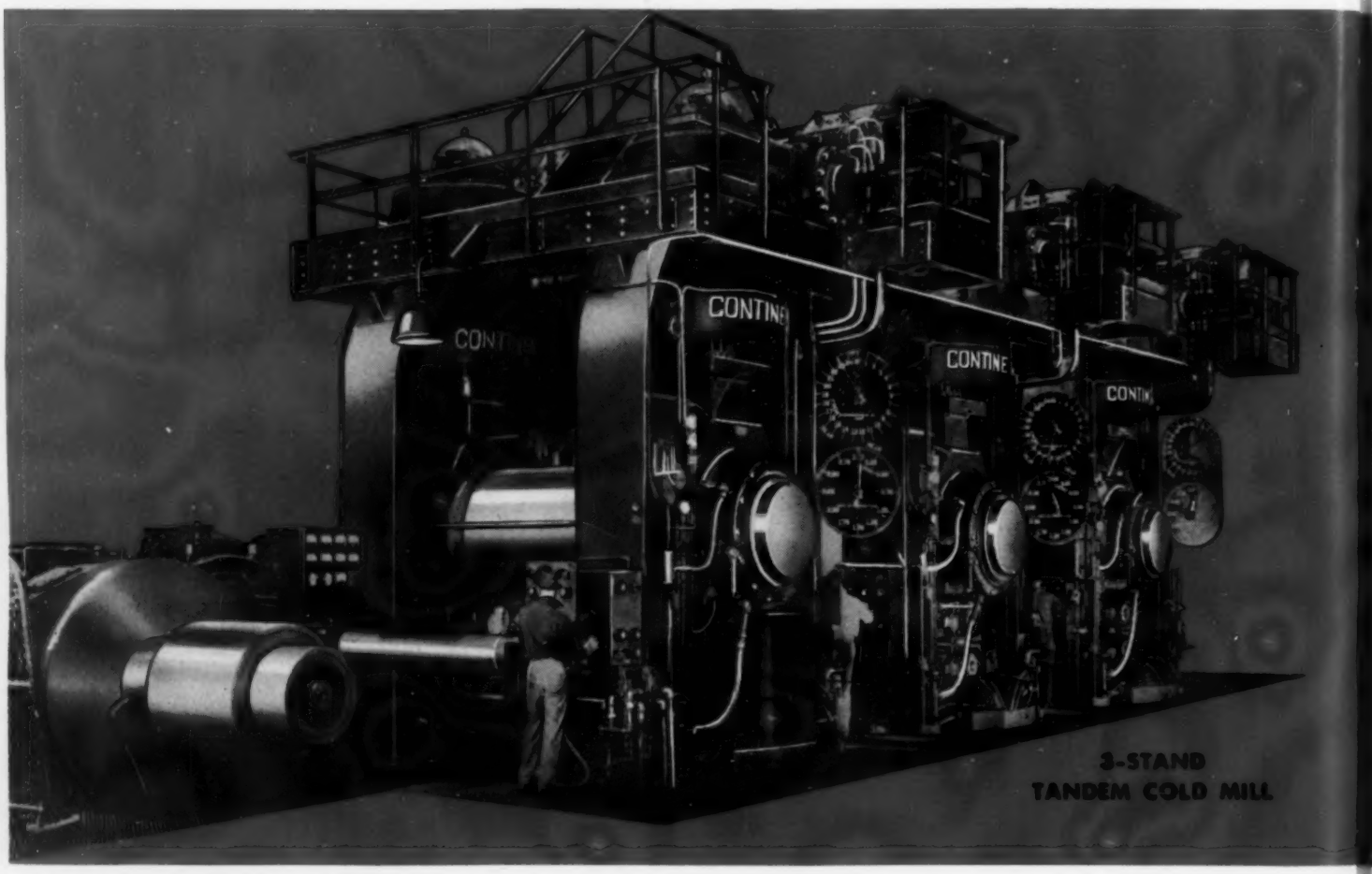
Continental **ROLLING**

of all types, including auxiliary



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Structural Mills	Slabbing Mills	Roll Lathes	Transfers
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Billet Mills	Hot Strip Mills	Charging Box Cars	
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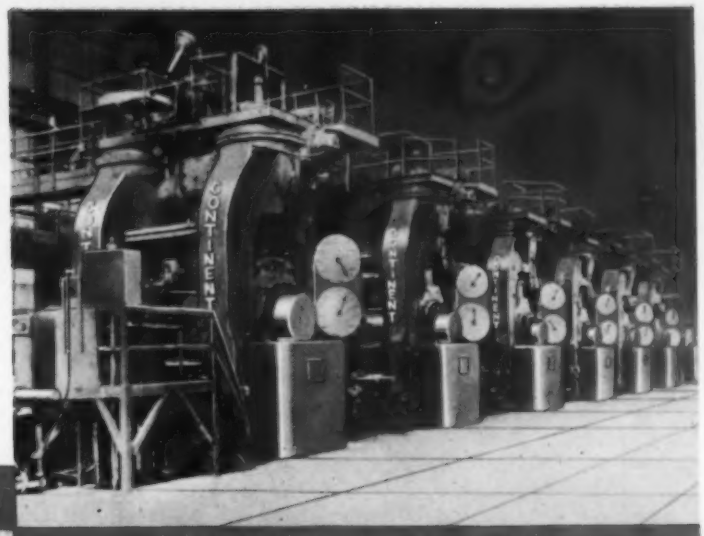
IRON, ALLOY IRON and STEEL ROLLS for ferrous and non-ferrous rolling mills; pulp and paper industry; textile industry; and milling, cereal and vegetable oil industries.

* * *

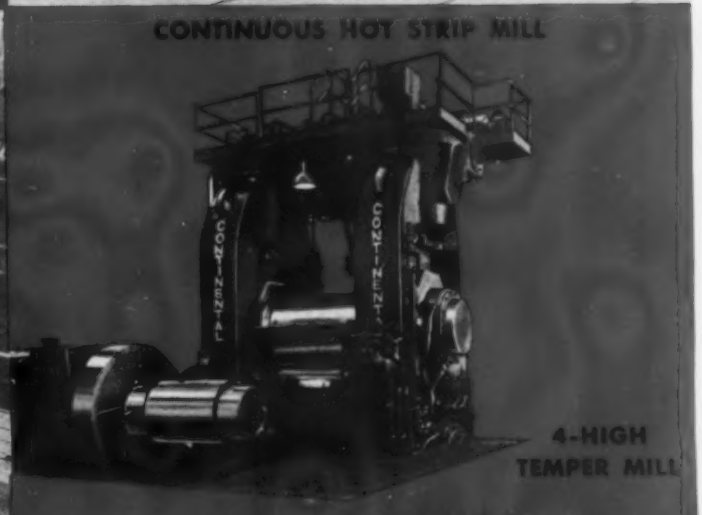
CARBON and ALLOY STEEL CASTINGS from 20 to 250,000 pounds. Complete heat treating and machining facilities.

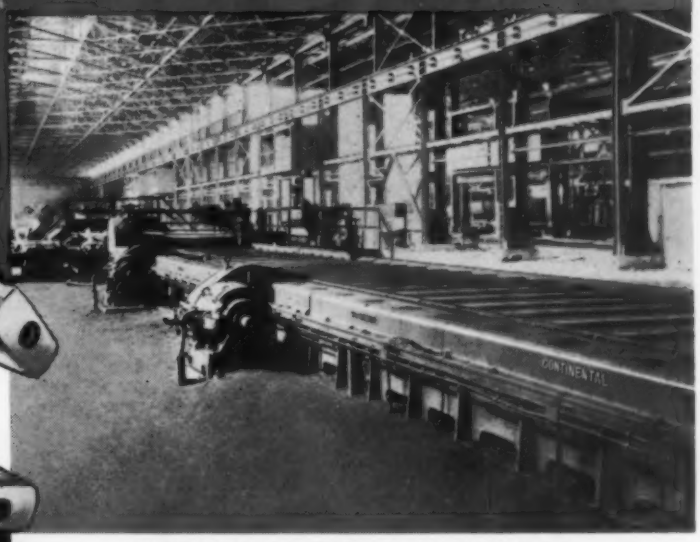
MILLS

equipment



CONTINUOUS HOT STRIP MILL





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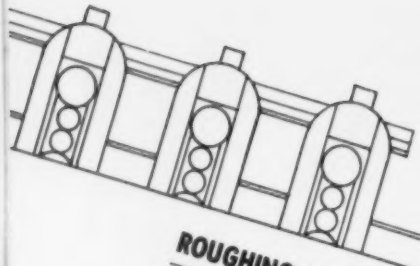


ROUGHING MILL STANDS

WORK ROLLS { Pittsburgh Grade 35 • Pittsburgh Grade 25

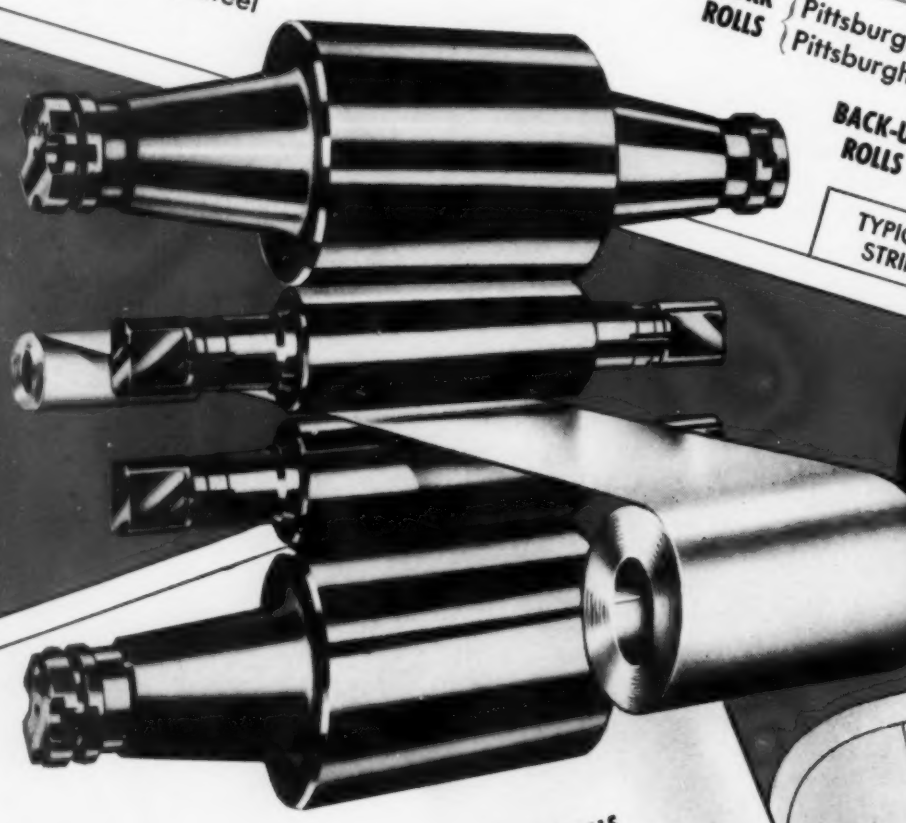
BACK-UP ROLLS { Phoenix "A" Alloy Steel

FINISHING MILL STANDS

WORK ROLLS { Pittsburgh Grade Special Process • Pittsburgh Grade 45 • Pittsburgh Grade 35

BACK-UP ROLLS { Phoenix "A" Alloy Steel

TYPICAL HOT STRIP MILL



There's a definite PHOENIX ROLL for each ROLLING requirement

TYPICAL TEMPER AND SKIN PASS MILL

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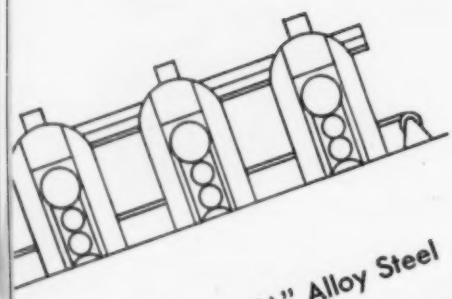
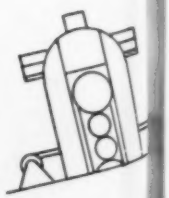
WORK ROLLS

Phoenixloy • Pittsburgh Grade 55 • Pittsburgh Grade 45 • Pittsburgh Grade Special Process



WORK ROLLS

Phoenixloy • Pittsburgh Grade 55 • Pittsburgh Grade 45 • Pittsburgh Grade Special Process



BACK-UP ROLLS { Phoenix "A" Alloy Steel • Phoenix "A" Special Alloy Steel

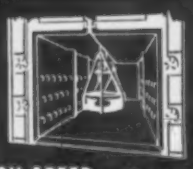
TYPICAL COLD REDUCTION STRIP MILL

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION OF BLAW-KNOX COMPANY • PITTSBURGH, PA.

Gradiation®

PRECISION TOOL FOR PRODUCTION WAR



HIGH SPEED radiant heat made possible the continuous heat treating of cast armor-plate for tanks with improved metallurgy.

FUNCTION FITTED radiant heat is speeding up forgings by one-third . . . is doubling die life.

DIRECT RADIANT heat has put heat processing of electronic glass tubes on a continuous, precise and automatic basis.

LIQUID HEAT TREATMENT of petroleum and chemicals assures more and better products . . . less space for equipment.

FAST DRYING with radiant heat . . . continuous strip of roofing felt, paper, textiles . . . paints . . . coatings . . . even instantaneous ink drying at paper speeds of 1000 fpm., *plus*.

SELAS GRADIATION offers American industry "*production-engineered processing*" . . . key to improved methods and product quality . . . assurance of new highs in output.

GRADIATION—the newest concept of high-speed heat processing—*proved* during World War II, *improved* since . . . utilizes radiant heat as a precision tool for increased production. Combines high-temperature, automatic operation, precise controllability and protective atmosphere. Where *production* depends on heat processing, let Selas engineers prove *Gradiation* saves manpower, time, material and money.

SELAS CORPORATION OF AMERICA

PHILADELPHIA 34, PENNSYLVANIA

today's best buy is better air!

Electro-MATIC super-clean air

PAYS A PROFIT!

THIS appears to be a modern steel mill installation of AAF Electro-Matic filters supplying *super-clean* air to a motor room. Actually it is an installation in Kaufmann's Department Store, Pittsburgh, which goes to prove that *super-clean* air is a profitable investment in many types of business.

Developed exclusively by AAF engineers, the Electro-Matic is the only automatic, self-cleaning, electronic precipitator. It is widely used not only in steel mills, but in textile, pharmaceutical, chemical and other industries, as well as commercially. The Electro-Matic maintains high efficiency filtration of fractional micron particles—such as smoke and fumes—in addition to coarse material. The filters are standardized, self-contained units easily installed in various arrangements to meet any air volume requirement.

Exclusive features of the Electro-Matic are its automatic operation and self-cleaning function. This combination reduces servicing to routine maintenance and insures maximum operating efficiency at all times. The installation above . . . like so many in the steel industry . . . is equipped with oil clarifiers which continuously clean the Viscosine and simplify sludge removal.

AAF makes the *only* complete line of air filters and electronic precipitators. If you have a problem requiring *super-clean* air see your nearby AAF representative or write today for our Electro-Matic Engineering Bulletin No. 250-E.

AAF

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Here's How to Erase Smoke Troubles

VIOLATION OF SMOKE ORDINANCE

LOSS OF FUEL ECONOMY

BAD COMMUNITY RELATIONS

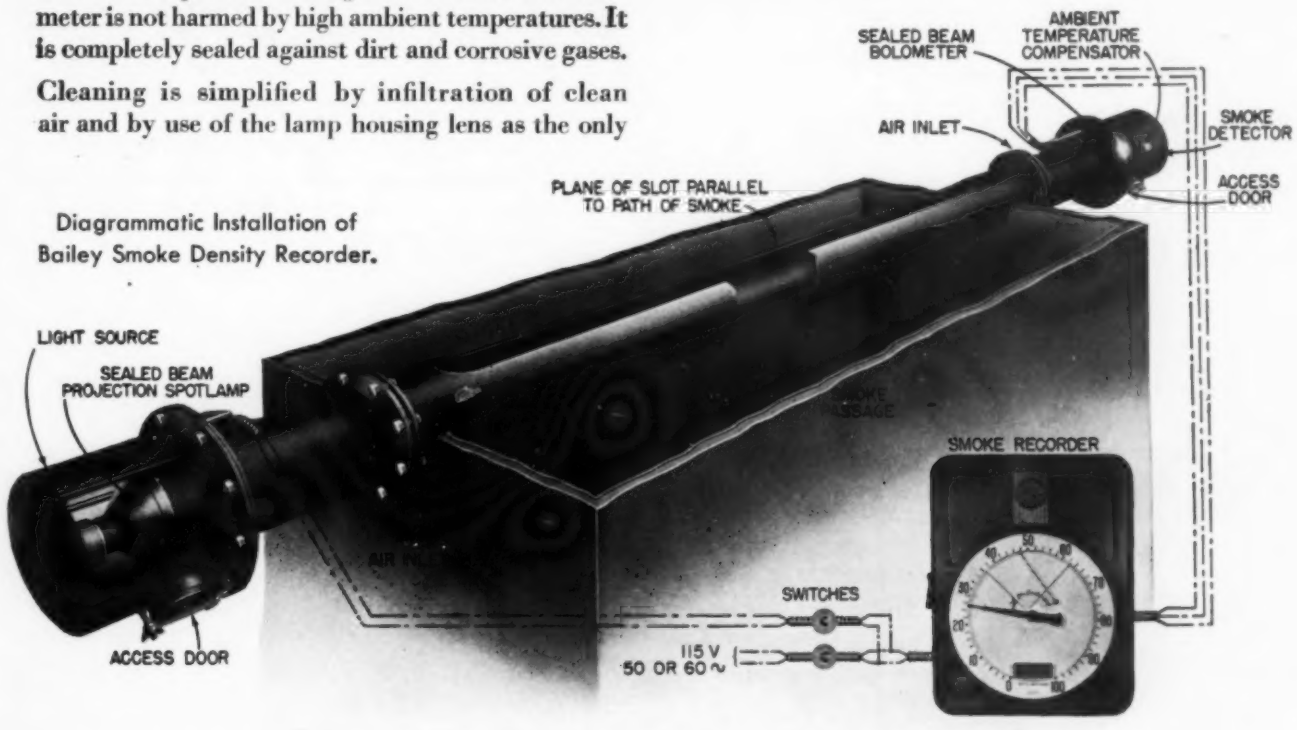
★ One of your first steps in erasing these troubles which result from excessive smoke, should be the installation of a Bailey Smoke Density Recorder. This 24-hour recorder is not an ordinary photo-cell instrument. Instead it detects smoke density by a Bolometer which is simply a sturdy tungsten filament and a parabolic mirror, mounted in a standard sealed beam automobile head lamp housing.

In using this simple, unique smoke detector, you do not have to provide cooling devices since the Bolometer is not harmed by high ambient temperatures. It is completely sealed against dirt and corrosive gases.

Cleaning is simplified by infiltration of clean air and by use of the lamp housing lens as the only window between the Bolometer and the gas passage.

It's easy to secure and maintain alignment of the sealed beam light source with the Bolometer since they are mounted at opposite ends of a slotted pipe which extends across the smoke passage.

For complete information on how you can profitably use this unique instrument to erase your smoke troubles, ask for Bulletin 211, "Bailey Smoke Density Recorder".



Diagrammatic Installation of Bailey Smoke Density Recorder.

G-29

BAILEY METER COMPANY

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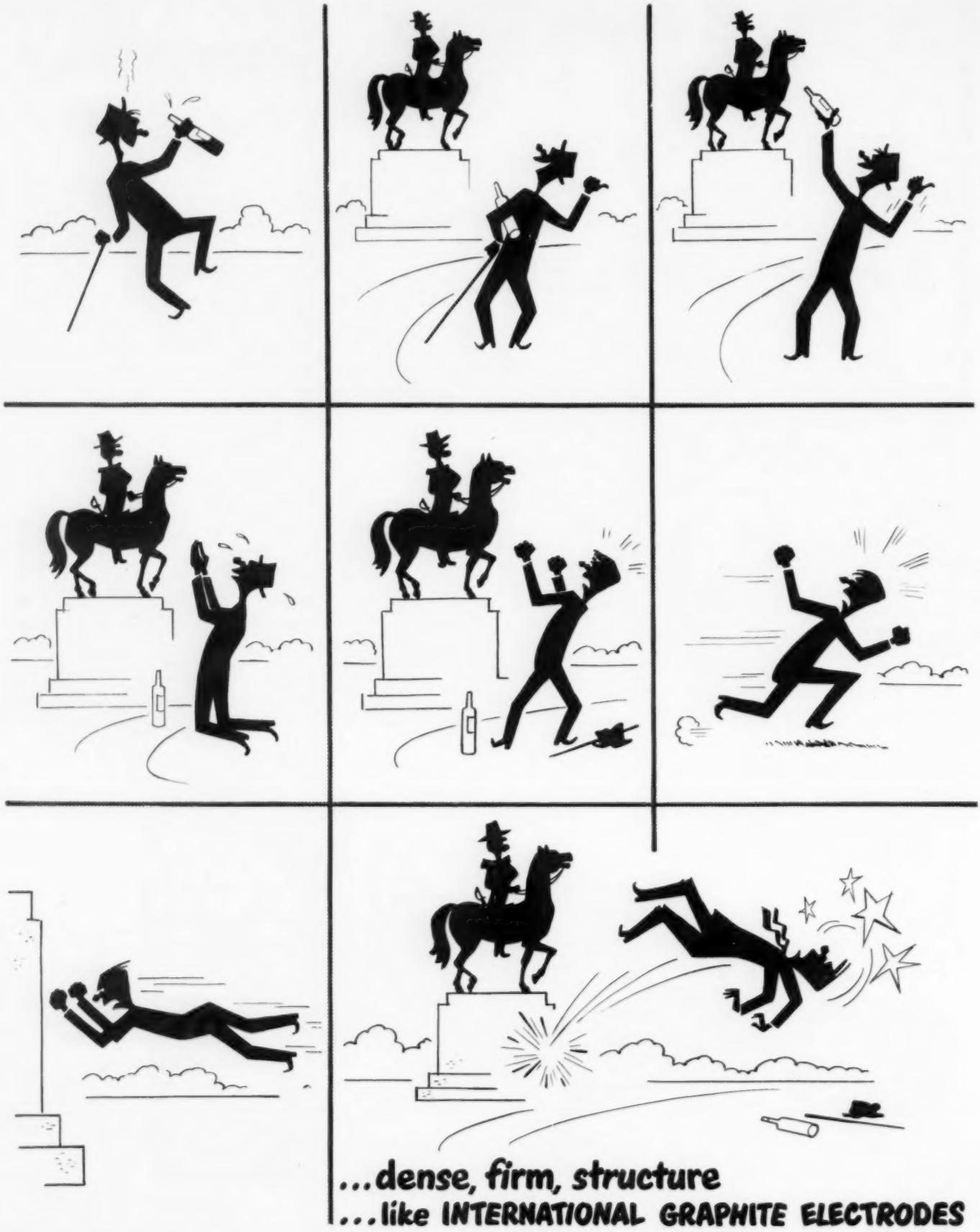
BAILEY METER COMPANY LIMITED, MONTREAL, CANADA

Let Bailey Smoke Density Recorders Watch Your Stacks

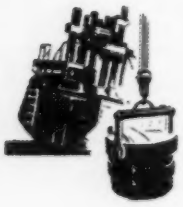


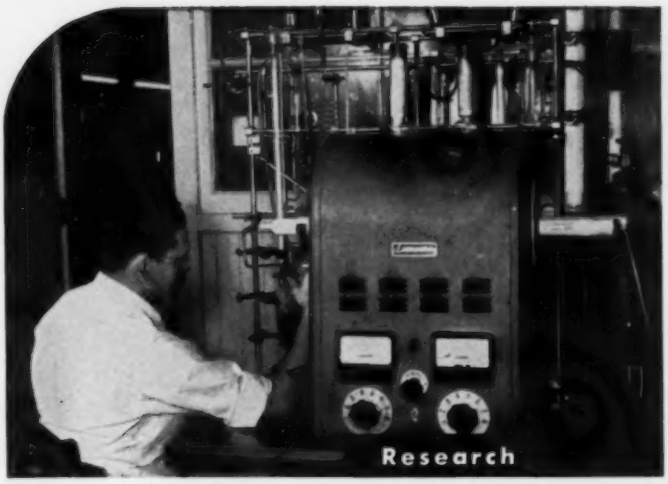
...dense, firm, structure
...like INTERNATIONAL GRAPHITE ELECTRODES

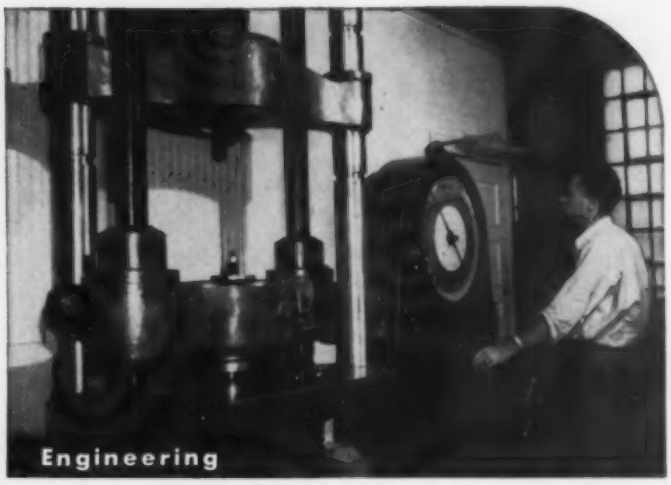
INTERNATIONAL *Graphite & Electrode* **CORP.**

A SPEER CARBON COMPANY SUBSIDIARY

ST. MARYS, PENNSYLVANIA







WHICH

N.B.M. service is most important

FOR PRODUCING BETTER BRONZE BEARINGS AND CASTINGS?

The answer is that *ALL FOUR* are equally important... and ALL FOUR represent the reasons why more and more users of Non-Ferrous Bearings and Castings become N-B-M Customers.

The complete facilities of National Bearing Division for Research, Engineering, Production and Finishing are unique. They represent an important *chain of service*—an ability to translate your *problems* into *requirements,* and requirements into *actual products* that serve you better.

The most modern equipment for alloy testing, molding, casting and finishing assures you of finer, more dense, closer-to-size bearings and castings—products that have higher resistance to wear and greater long-range economy.

Yes, this complete N-B-M Service is worthwhile investigating. Call in your nearest N-B-M Representative—he will gladly show you how this service can be geared to serve you with maximum efficiency.

THIS NEW CATALOG completely describes N-B-M Facilities—how they can cut costs for you and tie in with your own production. Write for a free copy today.

AMERICAN Brake Shoe COMPANY

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PLANTS IN: ST LOUIS, MO • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

New tighter fit

So positive is the fit between seat and plate on this time-tested Brosius-Westling Goggle Valve, that the unit pressure is comparable to that found on flange gaskets in pressure piping. In addition to this new feature, distortion is eliminated due to heavy construction and separation between barrel and frame... moreover, manual operation is easy and fast even after long periods of idleness. Numbers of these valves are currently contracted for, yet capacity has not been reached and your inquiry is invited.

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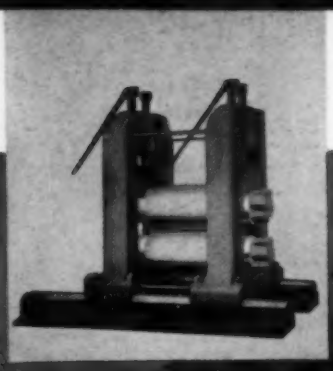
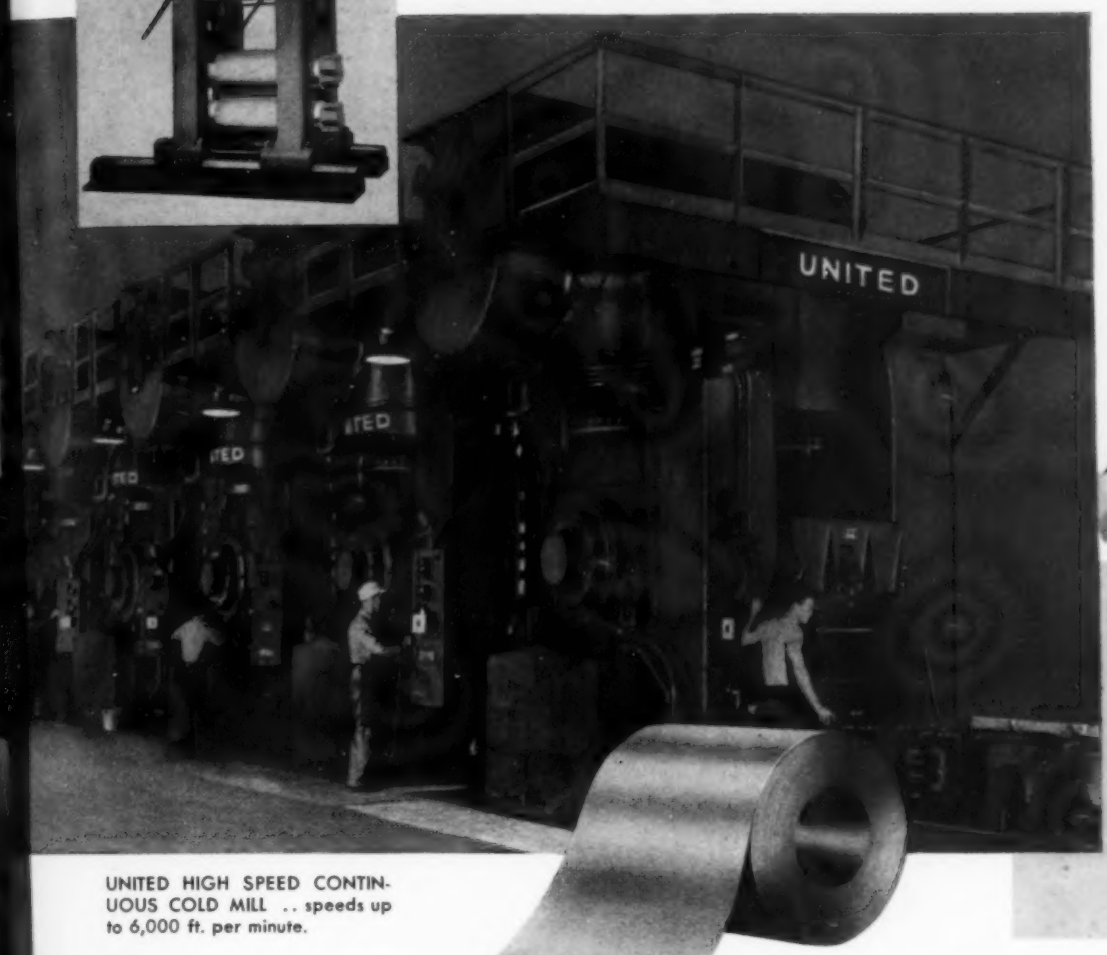
Salem - Brosius, Inc., Pittsburgh 15, Pa.

Affiliates: Salem Engineering Division, Salem, Ohio;

Salem Engineering Co., Ltd., Milford on Derby, England; Salem Engineering (Canada) Ltd., Toronto, Canada



EARLY COLD MILL . . . about 1901



UNITED HIGH SPEED CONTINUOUS COLD MILL .. speeds up to 6,000 ft. per minute.

50 YEARS AGO

Mom Did Most of the Canning

BUT not any more. Today, the world's choicest foods, with all their goodness and flavor locked in neat, sanitary tins, reach our pantry shelves in infinite variety and abundance.

The phenomenal growth of the canning industry—America's largest user of tin plate—would not have been possible without the development of new and better steel rolling and coating processes.

In the contributions to better living that United has been able to make through a half century of pioneering in the design and construction of more efficient rolling equipment, it takes great satisfaction.

As always, United's engineers will be glad to work with you on your plans for increased tin plate production.

Designers and Builders of Ferrous and Non-Ferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.

1901 Golden Anniversary 1951

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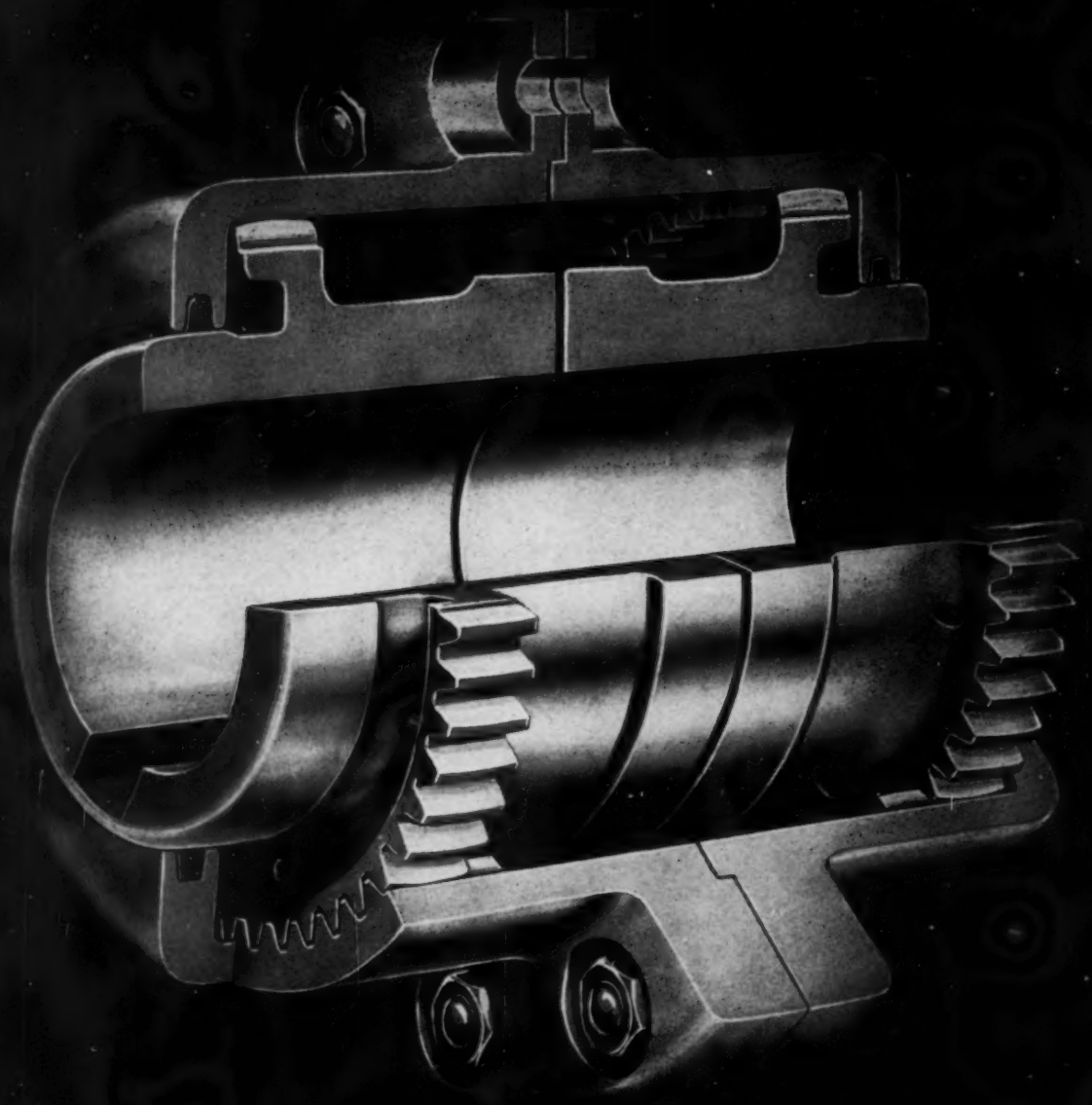
POOLE



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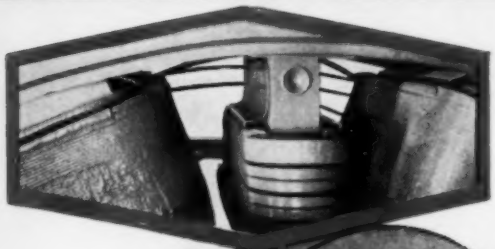
FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

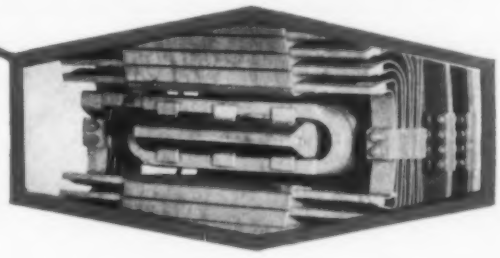
Elliott [redacted]-STEEL DC Motors stay on the job . .

. . . built with carefully planned rugged construction of each part, enabling them to stay in service without costly and time-consuming repairs.



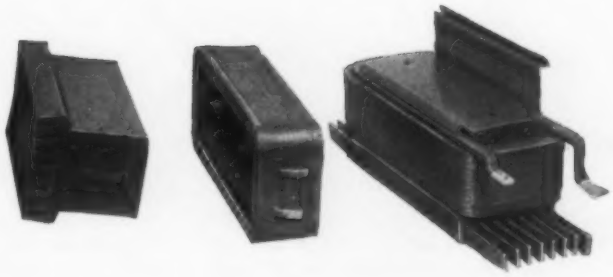
Coil tighteners compressed between the frame and coils.

FIELD FRAME—Coils and windings readily accessible for cleaning or maintenance, yet rigidly braced against movement and chafing without resort to the use of cording or wood blocking which deteriorates with age; fully compensated rectangular type bar winding with joints silver-alloy brazed; thick, split frame, of minimum length, gives unusual stiffness and allows better cooling and access to field windings.

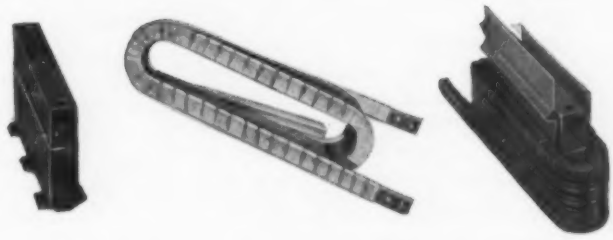


Non-magnetic steel fingers welded to commutating pole piece.

MAIN FIELD POLE, COILS, AND COIL TIGHTENERS—Pole insulation built into shunt coil from inside and folded over outside of coil at top and bottom and anchored by turning it under last layer of conductors; top and bottom corners of coils, where not covered by pole insulation, protected with mica corner pieces extending under pole insulation; radial and side movement of coil prevented by pressure of corrugated steel coil tighteners between frame and pole; steel spacers welded to pole ends prevent axial movement.



COMMUTATING FIELD POLE, COIL, AND COIL TIGHTENERS– Conductors insulated from pole by U-shaped channels inserted over each turn from inside coil; canvas phenolic strips taped to top and bottom of coil; radial, axial and side movement of coil prevented by pressure of corrugated steel coil tighteners between frame and non-magnetic fingers welded to inner end of pole piece.



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MR-3

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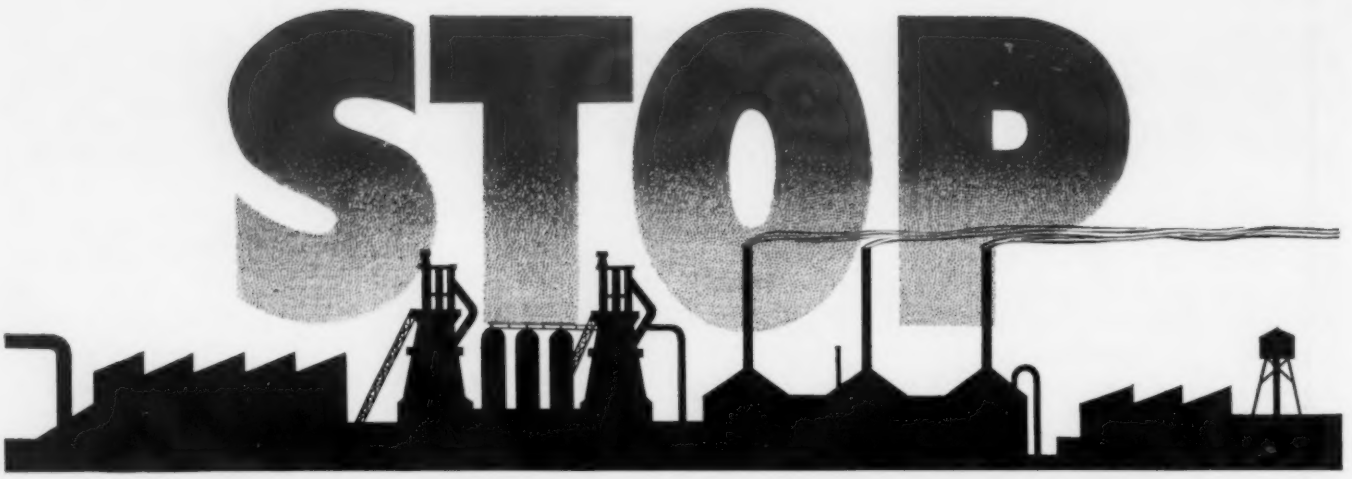
STOP RUST WITH RUST-OLEUM



Why let rust—the most destructive enemy of American Industry—rob you of expensive, hard-to-replace machines, tanks, stacks, fences, pipe, metal sash, fire escapes, and other valuable equipment?

Use RUST-OLEUM in your plant to protect your property. For 25 years RUST-OLEUM has proved its capacity to stop rust for many nationally known manufacturers. Its tough, pliable, rust-resisting film gives excellent protection that prevents rust losses under many difficult rust-producing conditions—salt air, dampness, industrial fumes, and general weathering.

RUST-OLEUM can be applied *even* over rusted surfaces. It is not necessary to remove all the rust. Just remove scale and loose rust by cheap scrapers and wire brushes. You save time and labor on maintenance because no chemical precleaning or sand blasting is usually required.

A qualified RUST-OLEUM specialist will be glad to survey your rust problems and help you develop a program of plant-wide rust control to defer many costly replacements — to conserve the available supply of new metal for national defense.

Industrial Distributors in principal cities of the United States and Canada carry complete stocks for immediate delivery. Plan your needs—order *now!* See our complete catalog in *Sweet's* which also tells the nearest source of supply. Or, write on your company letterhead for full information.

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Available in many COLORS aluminum and white

Beautifies as it Protects

RUST-OLEUM CORPORATION
2443 Oakton Street, Evanston, Illinois

TUBE MILL CRANES

When your Tube Mill Cranes are "Shaw-Box," you are assured efficient, low-cost crane service with minimum maintenance and time out of service — the plus advantages of "Shaw-Box" experience, advanced engineering techniques, and precision manufacturing methods.

Built to withstand the most severe and exacting demands, "Shaw-Box" Tube Mill Cranes are recognized for their outstanding performance records and dependability in mills all over the country. Their simple, rugged, and extremely accessible construction makes each of them outstanding as an example of the cranes steel men strive for in their individual mill or AISE specifications.

That is why, for the greatest value your crane dollar can buy, always look to "Shaw-Box."

Be sure to send your inquiries for Steel Mill Cranes and Soaking Pit Carriages to "Shaw-Box."

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SHAW-BOX CRANE & HOIST DIVISION
MUSKEGON, MICHIGAN

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties.
Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves,
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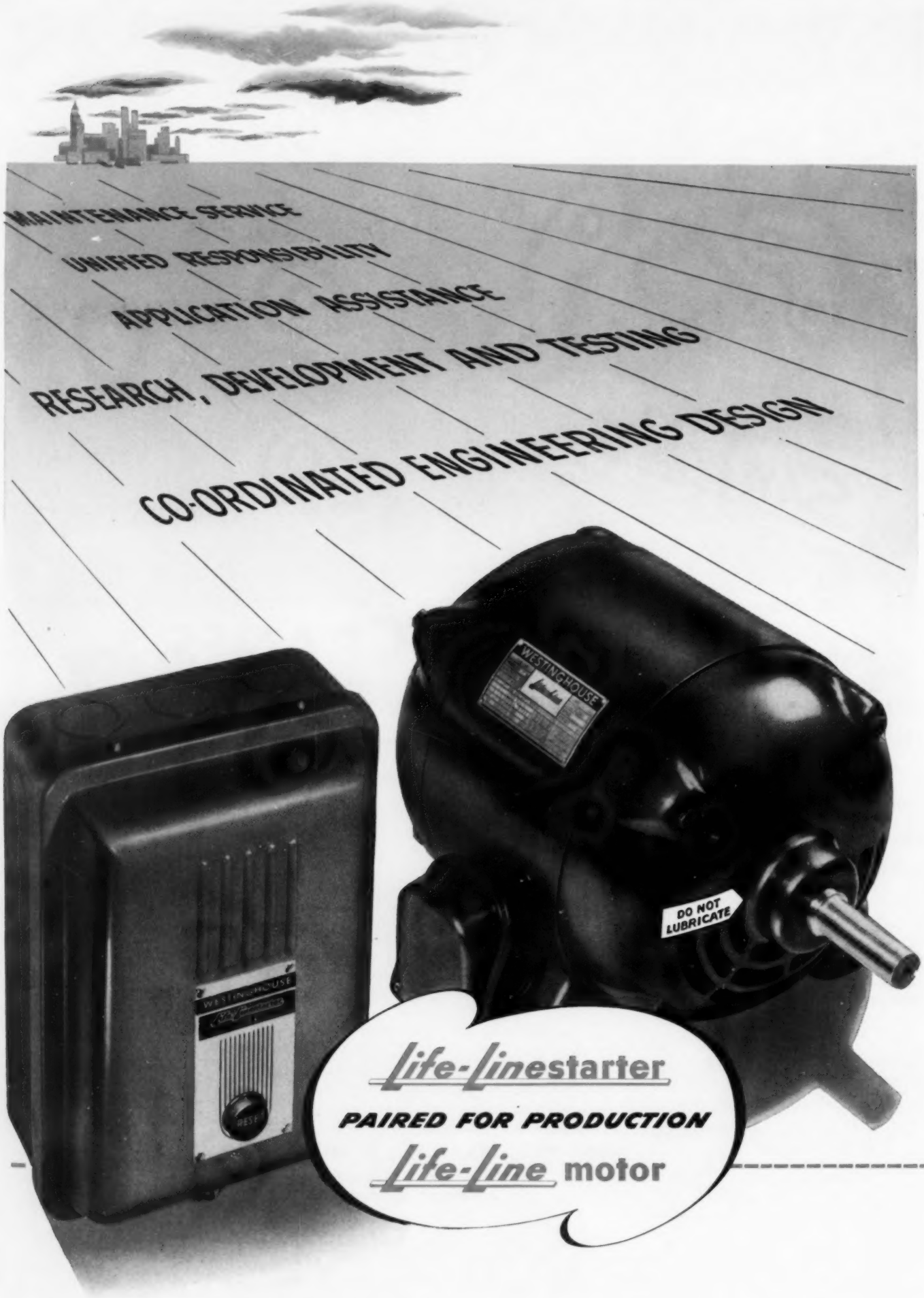
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DO NOT LUBRICATE
Life-Linestarter
PAIRED FOR PRODUCTION
Life-Line motor

EXTRAS like these assure long-range performance

You get more than a motor and a starter when you install these Life-Lines. You get complete design, engineering and service every step of the way.

CO-ORDINATED ENGINEERING DESIGN makes sure that Life-Line motors and Life-Linestarters give long-range performance. They're made together to work together.

RESEARCH, DEVELOPMENT AND TESTING in Westinghouse laboratories result in such features as:

Steel frame
Pre-lubricated bearings... in Life-Line motors
"De-ion"® arc quenchers
Bimetallic relays . . . in Life-Linestarters®

APPLICATION ASSISTANCE to help you select the right motor and control.

Application engineers for your daily problems
Consulting engineers for special design problems
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All at your service without obligation.

UNIFIED RESPONSIBILITY . . . for operation of the motors and protective controls.

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MAINTENANCE SERVICE is all-inclusive and nationwide.

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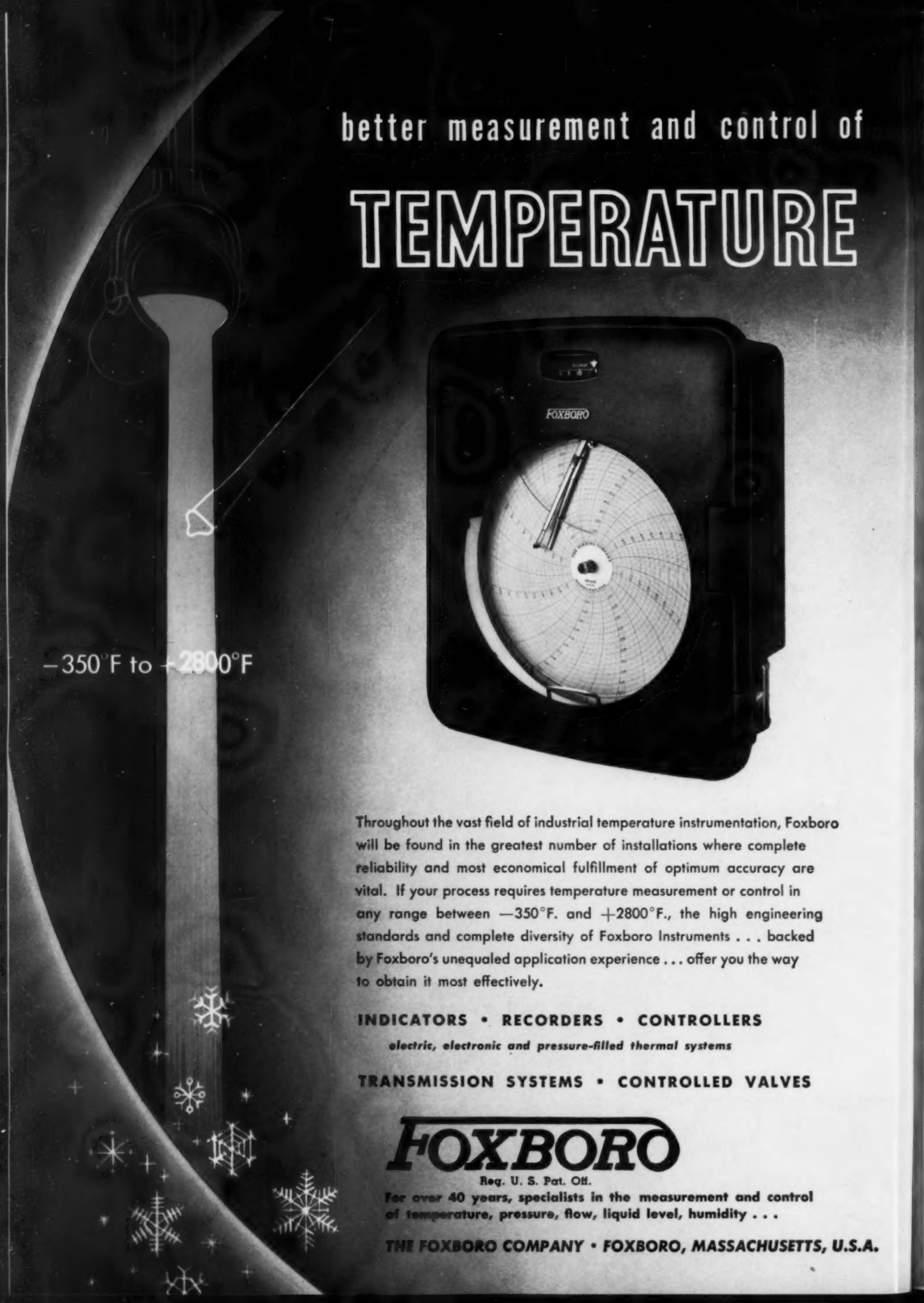
YOU CAN BE SURE.. IF IT'S
Westinghouse
Life-Line
MOTORS and CONTROLS

better measurement and control of

TEMPERATURE



Throughout the vast field of industrial temperature instrumentation, Foxboro will be found in the greatest number of installations where complete reliability and most economical fulfillment of optimum accuracy are vital. If your process requires temperature measurement or control in any range between −350°F. and +2800°F., the high engineering standards and complete diversity of Foxboro Instruments . . . backed by Foxboro's unequaled application experience . . . offer you the way to obtain it most effectively.

INDICATORS • RECORDERS • CONTROLLERS

electric, electronic and pressure-filled thermal systems

TRANSMISSION SYSTEMS • CONTROLLED VALVES

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For over 40 years, specialists in the measurement and control of temperature, pressure, flow, liquid level, humidity . . .

THE FOXBORO COMPANY • FOXBORO, MASSACHUSETTS, U.S.A.

Pennsylvania

...an important name in transformers

Sound management, thorough knowledge of the product, and good workmanship combine to make Pennsylvania Transformer Company an important Name in the transformer industry.

The trust placed in the Pennsylvania product is emphasized by the fact that orders for 60,000, 70,000, and 100,000 Kva transformers are now being filled in Pennsylvania's modern plant.

A special planning department, which devotes all of its time to research and development work, has introduced many fundamental transformer improvements. These include the Pole Star Distribution Transformer, the Standard Parts Power Transformer, the Straight Line Tap Changer, Precompressed Helical and Pancake Coils; and Pennsylite, a new laminated low loss material for terminal boards in underload tap changing equipment.

DISTRIBUTION
3 Kva to 500 Kva, Up to 66,000 Volts

50 Kva, single phase, 2400-120/240 Volts

POWER
667 Kva to 100,000 Kva, Up to 230,000 Volts

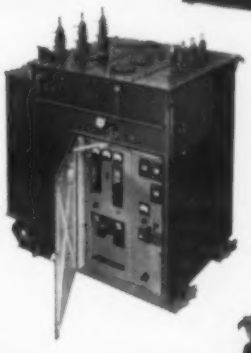
35,000 Kva, 3 phase, 115,000Y - 13200 Δ Volts

FURNACE
All Kva sizes and current ratings

15000 Kva with motor-operated tap changer

INTEGRAL UNIT SUB-STATIONS
Single circuit and double ended unit substations

1500 Kva single circuit unit substation

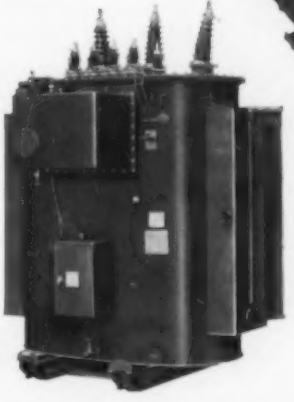


STEP VOLTAGE REGULATORS
Up to 750 Kva for plus or minus 10% regulation in 32 steps

300 Kva, 13800 volts, 32-5/8% taps

LOAD RATIO CONTROL TRANSFORMERS
For changing transformer taps under load.

2500 Kva, 3 phase, 66000-2500/4330Y X7500/12990YY Volts



Pennsylvania TRANSFORMERS

Pennsylvania TRANSFORMER COMPANY
CANONSBURG, PA. *Greater Pittsburgh District*

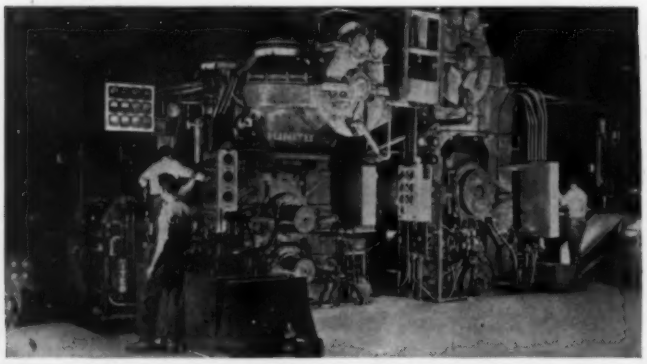
G-E drive holds accurate tension on world's fastest temper mill!

Teams up G-E amplidyne regulators with sensitive G-E regulating tensiometer to maintain uniformity and quality of steel strip—at 5000 fpm!

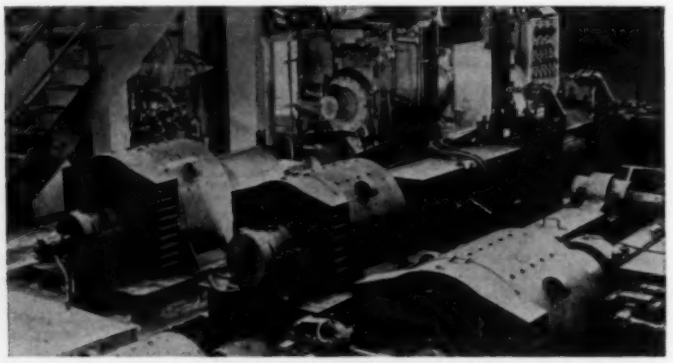
Almost a mile a minute! That's the record speed of this new two-stand temper pass cold strip mill, electrically engineered and equipped throughout as a unit by General Electric. Designed for greater steel output, this fastest mill of its kind benefits from such important features as these:

• **Full-range amplidyne tension regulators between stands and pullers, and pullers and reels, automatically compensate for all roll-diameter combinations, eliminating operator adjustments, simplifying operation.** • **Fast-acting, sensitive regulating tensiometer automatically maintains accurate tension between stands regardless of rolling-load distribution, helps assure uniform steel quality.** • **Individual-motor drive allows low-maintenance mechanical simplicity, reduces drive inertia for faster acceleration and deceleration, increased production.**

Here is further proof that G-E can handle successfully *any* steel-mill drive problem—including *yours*. Ask the G-E steel-mill specialist in your area to talk it over with your engineers. *General Electric Company, Schenectady 5, N. Y.*



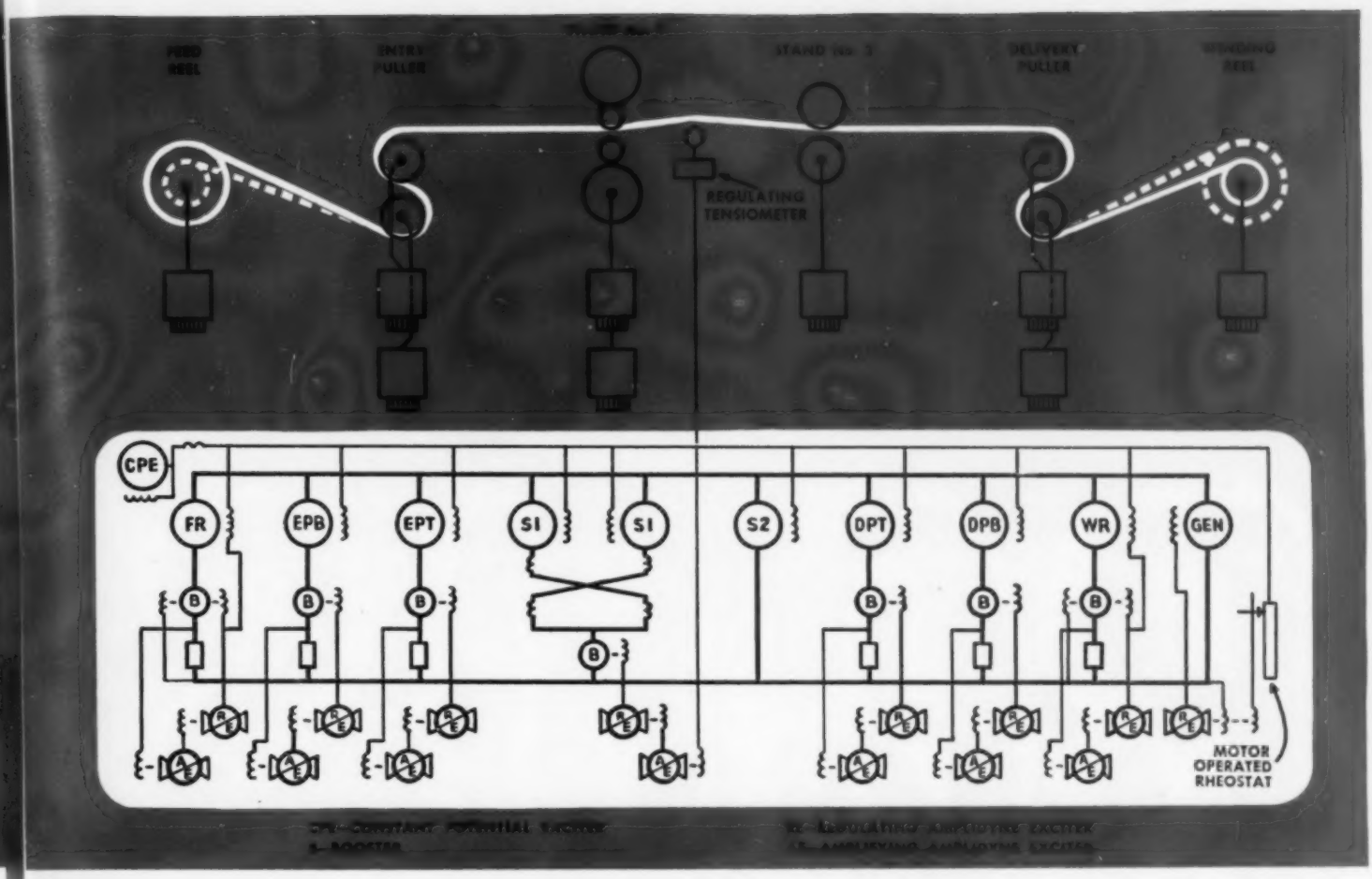
All electric equipment for this 5000-fpm temper mill—switchgear, motor-generator sets, drive and auxiliary motors, control, and ventilation apparatus—was engineered and supplied by General Electric, with G-E steel-mill specialists also helping on installation and tune-up.



Rear view shows four of the mill's 9 G-E 600-volt d-c drive motors (left to right): Stand No. 2 600-hp motor, two twin-drive 400-hp delivery puller motors, and 400-hp winding-reel motor. Extra-tough, these G-E motors, designed for metal-rolling service, are built to last in extra-tough steel-mill duty.

GENERAL ELECTRIC

659-81



HOW THIS G-E DRIVE WORKS:

All motors are connected to a common bus supplied by a single generator. The entire mill is accelerated and decelerated by armature voltage control of the main generator, provided by a motor-operated rheostat and an amplidyne voltage regulator. Stand No. 2 motor operates directly from bus voltage and with constant field strength, so that it acts as pace-setter for all of the mill's main drive motors.

Tension reels and pullers are provided with sensitive, compensated, amplidyne current regulators which maintain accurate tension at all speeds. Tension between stands, measured by a tensiometer, is compared with a reference standard set by the operator. Any difference between the two is translated by the amplidynes into a booster voltage which acts on the Stand No. 1 motor to produce the desired value of tension.

G-E regulating tensiometer helps speed up operations

An important factor in controlling the temper and flatness of the strip rolled in this mill, and in preventing strip breakage between stands, is the G-E regulating tensiometer, similar to the one shown. With a sensitivity that reacts to only 0.1 inch vertical displacement of the roll from low to high tension, it assures the fast, accurate response required—even at speeds greater than 5000 fpm. Moreover, tension is regulated continuously and to a closer degree than is possible by depending upon human judgment.

another example of
GENERAL ELECTRIC
drive engineering at work!

LEWIS ROLLS

Star in the performance of Rolling a better product

"X" AND "XA"
SUPERIOR "X"
AJAX DUPLEX
SPECIAL PROCESS
MOLYBDENUM CHILLED IRON
PLAIN CHILLED IRON
CLIMAX AND AJAX
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SPECIAL TUBE MILL ROLL

THE MARK OF A PERFECT ROLL BUILT TO FIT YOUR NEEDS

MANUFACTURERS OF
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FOR THE IRON, STEEL AND
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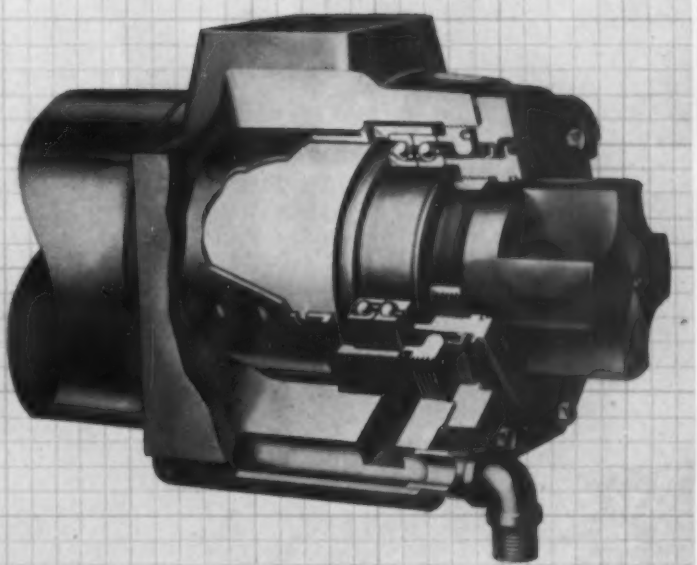
LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX CO.
PITTSBURGH, PENNA.

...team up for efficient performance

Morgoil and Torrington Roll Neck Bearings work together to handle tremendous loads and are used in a wide variety of mill applications—from reducing steel or cold brass slabs to rolling aluminum foil to .00025" thickness.

These roll neck bearings assure combined capacity for high radial and thrust loads... maintain close tolerances in the rolled product at higher speeds. The Torrington Thrust Bearings provide for exact pass alignment when rolling formed sections.

To help improve the operation of your equipment Torrington engineers will be glad to apply their wide experience in bearing design and manufacture.



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TORRINGTON BEARINGS

SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • NEEDLE • BALL • NEEDLE ROLLERS

It *costs more* to fix piping now!

No. 1615 Diaphragm Valve
Iron Body, Neoprene lined

You do less fixing

by using Dependable Quality

CRANE VALVES

...That's why more Crane Valves are used than any other make

better performing diaphragm valves

Separate disc and diaphragm design distinguishes these Crane Valves from all similar packless types. Life of diaphragm is multiplied because it's used only to seal the bonnet—not for seating. The separate disc seats the valve, eliminating wear and tear on the diaphragm.

Increased flow capacity ... reduced flow resistance ... tighter seating ... lower torque and fewer turns to operate ... are typical added features of Crane Diaphragm Valves. Wherever you use them, you can be sure of outstanding performance.

Such better quality and greater dependability mark Crane valves and fittings of every type—and assure the lowest ultimate cost.

CRANE

CRANE CO., *General Offices:*
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

WHY RISK THIS TO SAVE A DIME A WEEK?

The scrap pile of many a plant—whether it makes gears, bricks or gummed tape—thrives on poor temperature control. And the margin is often narrow . . . a variation of only a few degrees meaning thousands of dollars in rejected material or damaged equipment.

Yet many plants risk this loss without realizing it! They attack the temperature control problem correctly, by using potentiometer pyrometers to get top accuracy and dependability. But they sometimes slip on the "standardizing" adjustments which such instruments need to maintain those qualities. Overlooking the need for frequent and regular standardizing, these plants permit the operation to be done by hand . . . and thus possibly skimped or forgotten.

There is just one way of removing this threat to the accuracy of process temperature. It's by putting the standardizing responsibility where it belongs . . . directly on the recorders and controllers themselves.

A relatively simple device, the automatic standardizer, should be built into the potentiometer to handle this job. It checks the measuring circuit at least every 48 minutes . . . adjusts when necessary . . . *never forgets!* And this essential feature, amortized in the usual 10 years, costs less than 10¢ a week.

So, regardless of what make instruments you buy, be sure to specify automatic standardizing. It's cheap . . . safe . . . sure!

Write Leeds & Northrup Company, 4942 Stenton Avenue, Philadelphia 44, Pennsylvania.

AUTOMATIC STANDARDIZING Guards Product Quality When You Use Instruments Like These

Speedomax Potentiometer Instruments and Drive Unit (left) helping maintain production in an Ohio metal-working plant.

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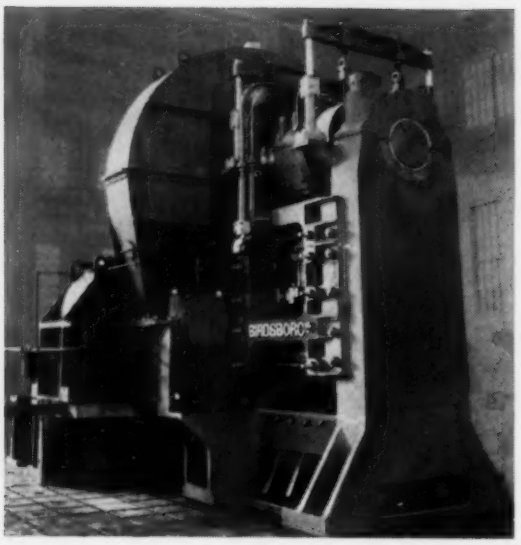
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.



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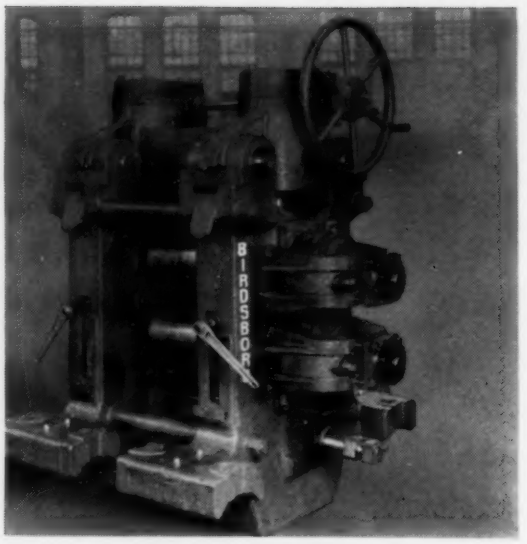
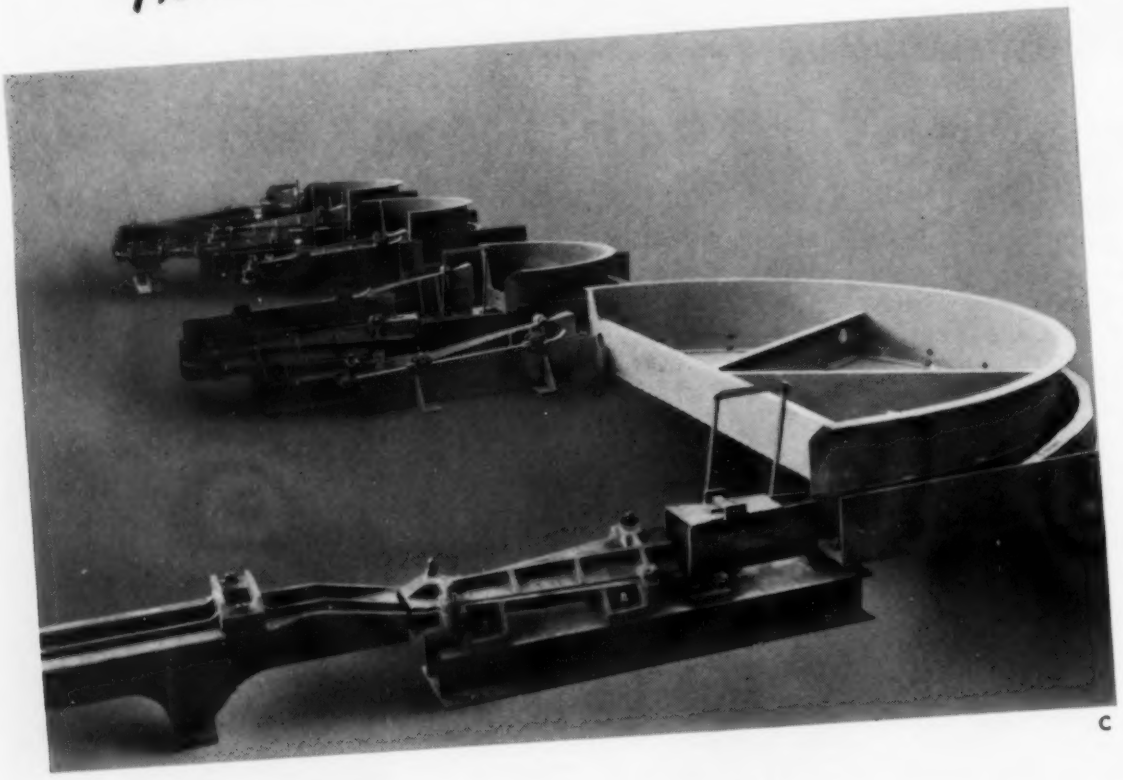


B

Engineered For High Production

● When the pressure is on for more and more output, look to BIRDSBORO's engineering skill for the machinery that will get you over the hump and keep you there. Call on us for help in modernizing your facilities to meet today's urgent demands.



C

A. 10″ x 10″ bloom and 6″ x 30″ slab shear.

B. 12″ continuous mill stand showing roller bearing end roll adjustment.

C. Shop view of group of flat repeaters.

BIRDSBORO

STEEL FOUNDRY & MACHINE CO.

Birdsboro, Penna.

STEEL MILL MACHINERY

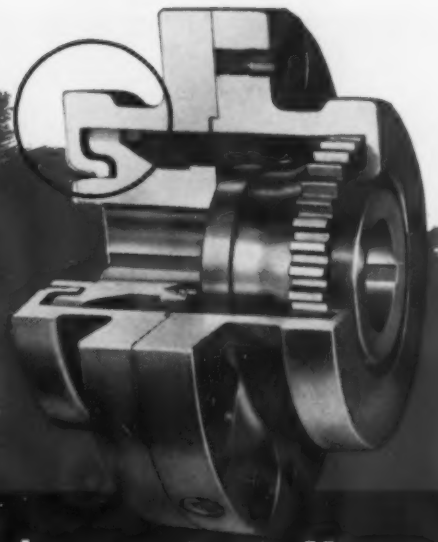
Designers and Builders of:

Steel Mill Machinery • Crushing Machinery • Rolls
Hydraulic Presses • Special Machinery • Steel Castings

Offices in:
BIRDSBORO, PA. AND
PITTSBURGH, PA.

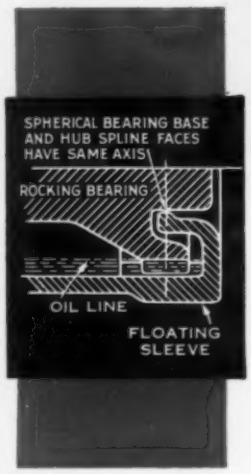
MM-14

NEED "SPECIAL" COUPLINGS?



Koppers Can Help You Save Money With *Easily Modified*

STANDARD Fast's Couplings



FOOLPROOF DESIGN: Instead of perishable oil seals, Fast's use a permanent metal-to-metal closure. Oil is always maintained at a safe level, whether the Fast's is running or standing still!

LOWEST COST: Fast's Couplings cost less per year because they normally outlast the equipment they connect. Original cost can be divided by 20 years or more. As one user says: *"We've had this Fast's Coupling since 1930 . . . it's apparently going to last forever!"* (Name on request.)

NEW DEVELOPMENTS: Fast's were the first gear-type couplings on the market. And they're first again with new designs developed by Koppers —like the revolutionary new Breaking Pin Coupling now available.

IF YOUR coupling problem looks tough—specify Fast's. Then Koppers' engineers can go to work, study your problem, and in many cases find a special coupling is not needed at all. Instead, these coupling specialists can often modify a *standard* Fast's Coupling and save you important money!

Standard Fast's Couplings can be modified for hundreds of unusual applications. Records kept over the past 31 years prove that Fast's Couplings outlast the equipment they connect. Fast's still maintains its original design, without basic change or sacrifice in size or materials.

Don't take chances. Whether your application calls for special or standard couplings, specify Fast's. For full information and specifications, write for your copy of Fast's free catalog today!

KOPPERS

FAST'S

THE ORIGINAL GEAR-TYPE

Couplings

INDUSTRY'S STANDARD FOR 31 YEARS

Mail COUPON TODAY FOR FREE CATALOG!

KOPPERS CO., INC., *Fast's Coupling Dept.,*
213 Scott St., Baltimore 3, Md.

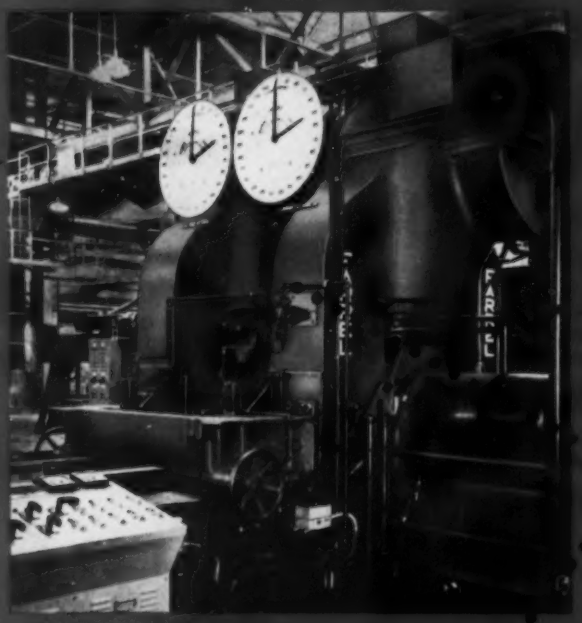
Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

Company.....

Address.....

City.....Zone.....State.....



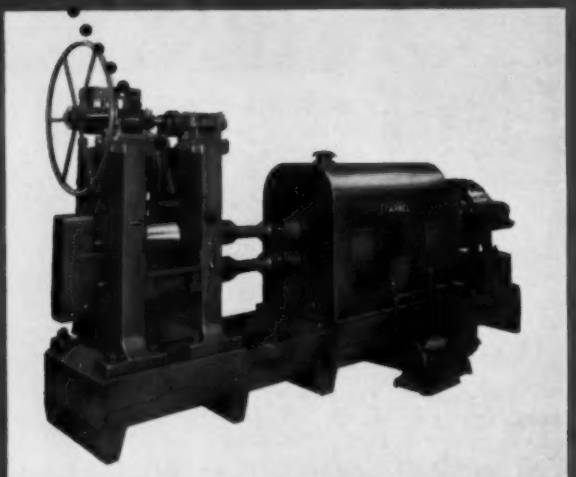
FARREL BUILDS NONFERROUS ROLLING MILLS *to suit your exact requirements*

Whether you need

A a giant breakdown mill . . .

B a tandem for producing copper rod . . .

C a laboratory unit for experimental work or any other type of mill, Farrel can build it to suit your needs exactly.



For almost a century, Farrel mills have been helping to solve rolling mill production problems. Designed to meet specific requirements, they are built in a wide range of types and sizes for rolling nonferrous rods, strips or sheets, as well as metal foils and cold strip steel. The company also designs and manufactures the reduction gear drives and pinion stands, coilers and special handling equipment required to make each installation a complete unit.

Farrel engineers are prepared to design mills for the solution of your production problems.

Write for quotations on mills for specific applications.

FARREL-BIRMINGHAM COMPANY, INC.

ANSONIA, CONNECTICUT

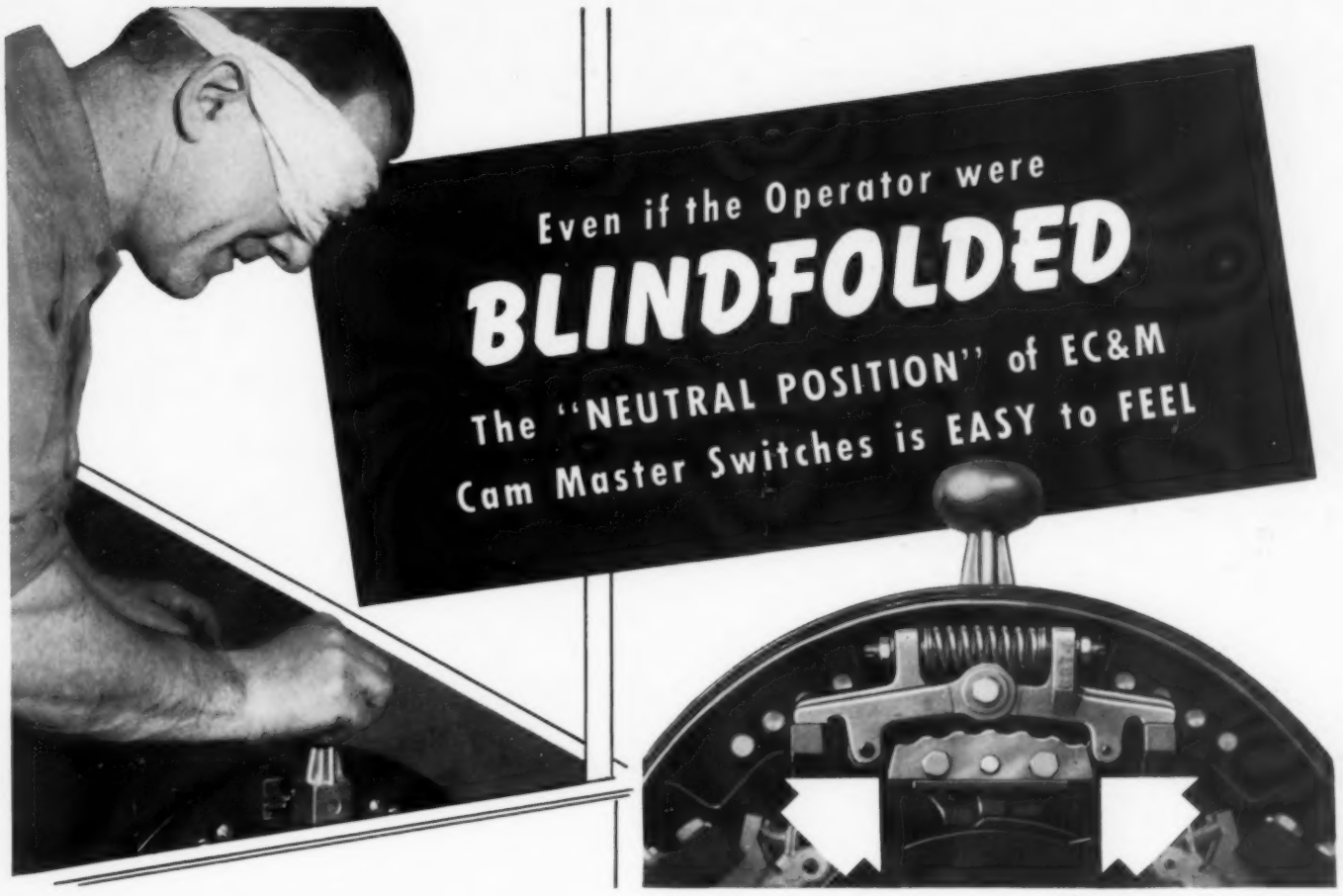
Sales Offices: Ansonia, Buffalo, New York, Akron, Pittsburgh, Chicago, Los Angeles, Houston

Plants: Ansonia, Conn., Derby, Conn., Buffalo, N. Y.

Established 1836

FB-653A

Farrel-Birmingham®

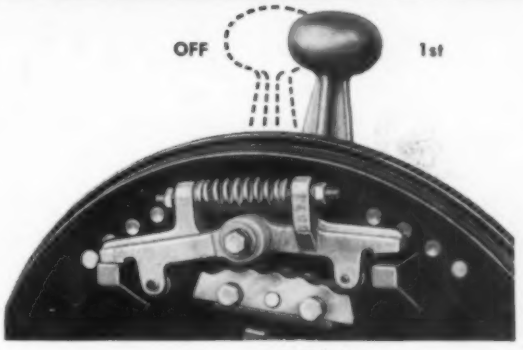


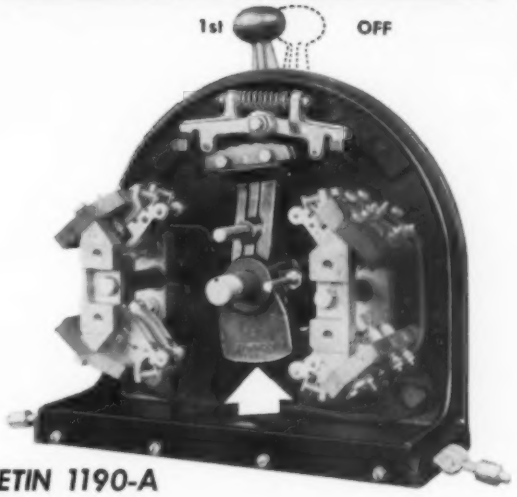
The off position of EC&M *improved* Cam Master Switches has a distinct feel. Like the automobile gear shift lever, there's a contrasting change between speed-points and when the lever goes into neutral. Rollers drop off the rails and there's a click as the roller-arm hits the stop from either direction.

Another important design feature maintains ability to inch easily. End-play clearance (up to 1/8") between the two rollers and rail-ends gives a "lift" when moving out of the off position to the first point, either forward or reverse.

Individual speed points are also readily distinguishable with this 2-roller and 2-rail design. One long, low-stressed spring exerts roller pressure. A counterweight below the main shaft offsets the weight of the aluminum operating arm—aids in keeping it on the speed-point selected—prevents self-advance of the arm if the master is accidently jarred or the crane bumped.

The enclosing cover overlaps the frame, keeping exterior dust out. On the inside, hardened rollers ride on hardened rails—large diameter cams speed opening and closing of coin-silver contacts. Try these improved EC&M Master Switches—they're unequalled for speed-control applications.





SPECIFY EC&M BULLETIN 1190-A

Cam Masters for Cranes—Mill Auxiliaries

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET • CLEVELAND 4, OHIO

For any kind of metallurgical construction

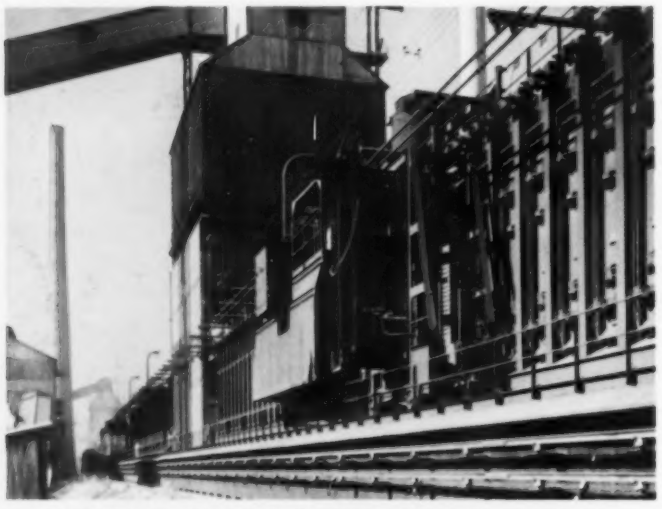
The installations pictured here give some indication of the scope of Koppers Metallurgical Engineering and Construction Services. Our Engineers and Management welcome the opportunity to consult with you.

ALL BRANCHES of the iron and steel industry *can count on Koppers* for comprehensive design, engineering and construction services, because Koppers Company is a specialist in the metallurgical field.

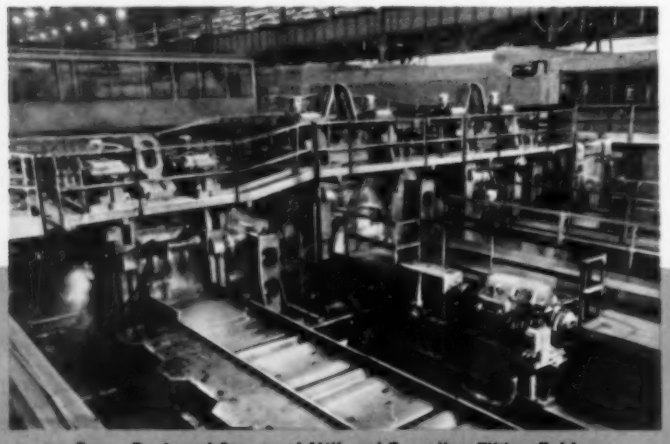
The Engineering and Construction Division of Koppers has long been recognized as a leader in the design and construction of coke-oven plants, auxiliaries and coal chemicals plants.

The Freyn Engineering Department of this Division specializes in the design and construction of blast furnaces, open-hearth furnaces and sintering plants . . . in the engineering of mills, power plants and other steel plant facilities.

Freyn-Designed and Constructed Sintering Plant. The sintering process permits *maximum* utilization of iron-ore fines and blast-furnace flue dust; also, it increases the pig-iron production of existing furnaces.



These 106 new Koppers-Becker Underjet Coke Ovens carbonize approximately 2,600 net tons of coal per day. Built in two batteries, they are equipped with Waste-Gas Recirculation and Blast-Furnace Gas Underfiring Equipment.



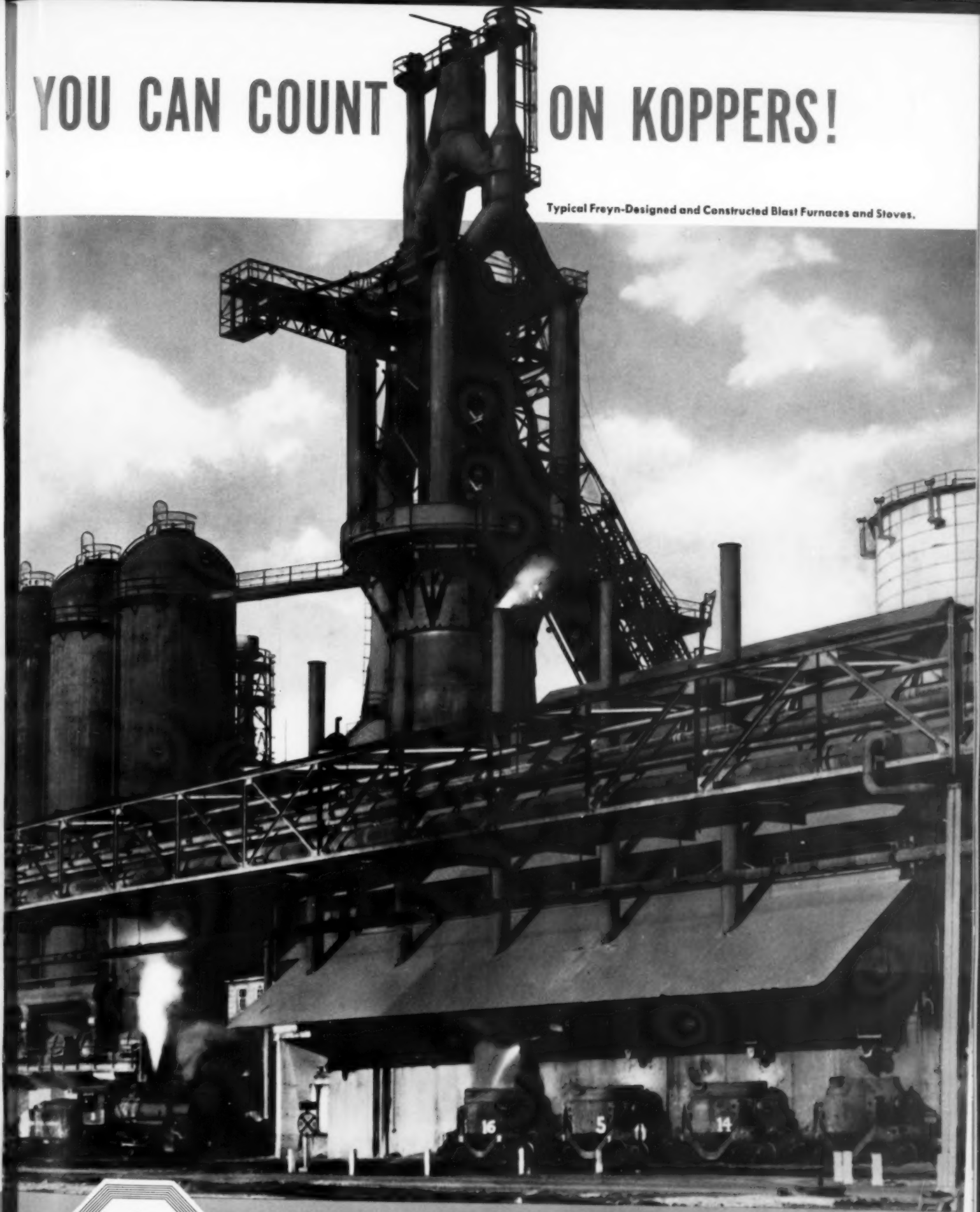
Freyn-Designed Structural Mill and Traveling Tilting Tables.

Freyn-Designed and Constructed Open-Hearth Furnaces.

This plant was constructed by Koppers for the recovery of ammonium sulphate, tar, light oil and pure benzol products from the carbonizing of 1,050 tons of coal daily.

YOU CAN COUNT ON KOPPERS!

Typical Freyn-Designed and Constructed Blast Furnaces and Stoves.



KOPPERS

Engineering and Construction Division

KOPPERS COMPANY, INC., PITTSBURGH 19, PA.

Tops

U.S. PAT. 2,781,067

LIKE SPEER MULTIFLEX BRUSHES

For high stability in operation

SPEER Carbon CO.

ST. MARYS, PENNSYLVANIA

Subsidiaries

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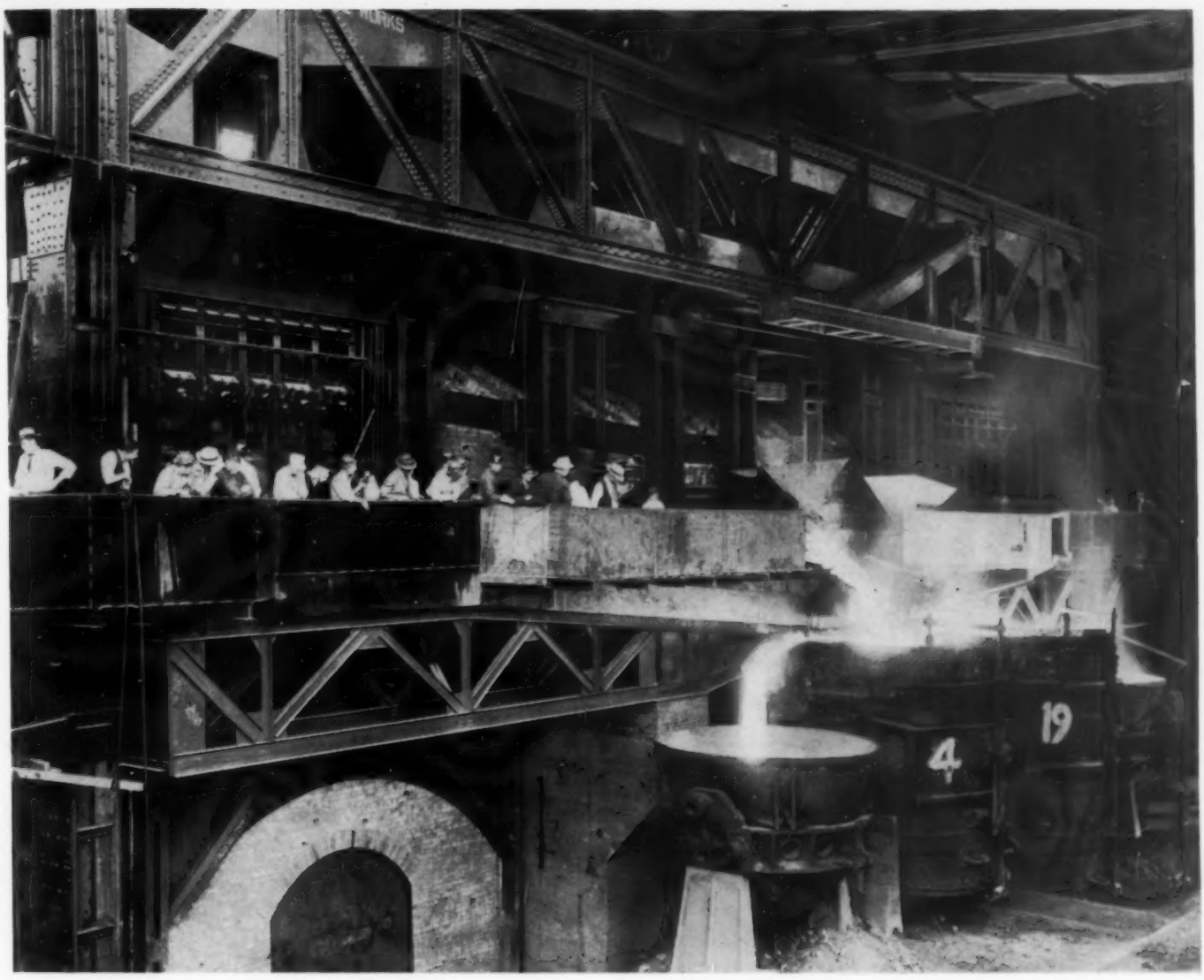


Economics of the All-Ramset Bottom in the World's Largest Open Hearth

TEN of the twelve open hearth furnaces of the Weirton Steel Company have full Ramset hearths. These hearths vary in age from 1½ years to 8½ years.

The record of No. 1 Furnace, the world's largest, is impressive. This furnace had produced 426,433.8 tons of ingots through February 26, 1951—an average of 801.6 tons for every day since it began operation on September 12, 1949.

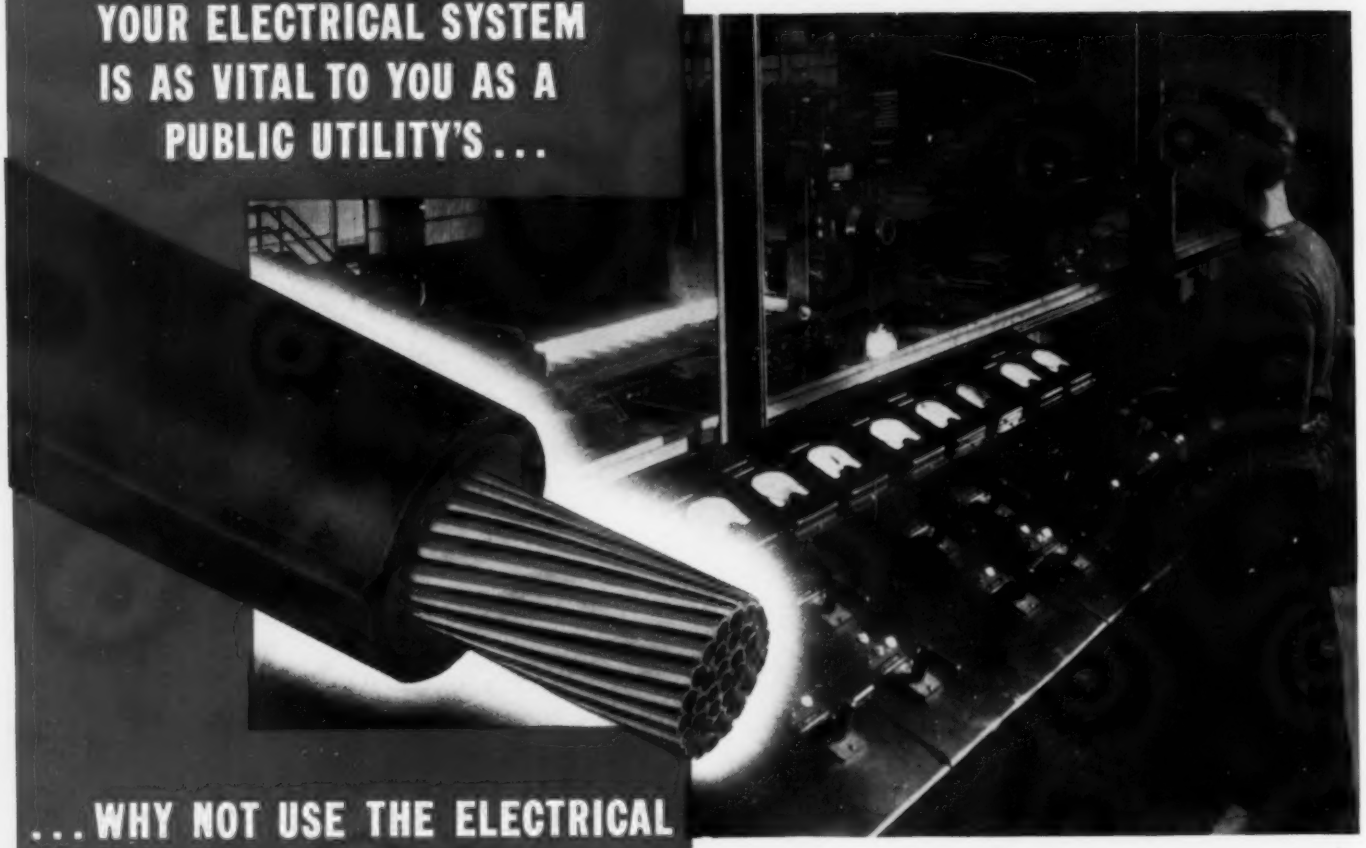
Success with Ramset hearths at Weirton, as at more than 150 other open hearth and electric furnace shops, is the result of three important factors—(1) use of the right refractory, (2) correct installation procedure, and (3) good maintenance practice.

Basic Sales and Service Engineers are always at your call—available for immediate consultation and help on any hearth problem involving granular basic refractories.

Basic Refractories Incorporated 845 HANNA BUILDING, CLEVELAND 15, OHIO

Exclusive Agents in Canada: REFRACTORIES ENGINEERING AND SUPPLIES, LTD., Hamilton and Montreal

YOUR ELECTRICAL SYSTEM IS AS VITAL TO YOU AS A PUBLIC UTILITY'S...



...WHY NOT USE THE ELECTRICAL CABLE THE PUBLIC UTILITIES USE?

Many steel mills maintain an electrical system as large and as vitally important as a public utility's. In any system that demands freedom from power interruptions, your safest buy for any circuit is a cable of the highest quality. Okolite-Okoprene is so regarded by public utilities, who consider it the most reliable and economical when all factors are considered.

Okolite-Okoprene is designed to withstand damaging elements of the kind found in steel mills. It is highly resistant to attack from chemicals used in fluxing, refining, pickling and desulphurizing . . . from lubricating oils and cutting compounds . . . from flame and high heats . . . and by mechanical damage.

As your guarantee of the highest possible electrical performance, the basic insulation is Okolite – made with natural Wild Up-River Fine Para rubber to obtain the optimum dielectric and aging properties.

The tough, expertly compounded Okoprene covering substantially contributes to the remarkable staying power of Okolite-Okoprene. Both the long-lived Okolite insulation and the Okoprene sheath are vulcanized simultaneously in a continuous metal mold. Together, these components represent years of cable research and manufacture and a performance record in the field exceeded by no other neoprene-jacketed cable.

Ask your local utility engineer about Okonite cables. He knows the familiar Okonite ridge on cable means long years of trouble-free service. The Okonite Company, Passaic, N. J.

OKONITE SINCE 1878

THE BEST CABLE IS YOUR BEST POLICY

insulated wires and cables

8564

Descale the DREVER way *

Continuous Stainless Strip Annealing and Descaling Line; Salt Descaling Bath and Water Spray Booth.

* without acid pickling ...either Continuously or by Batch Method

DREVER molten salt descaling furnaces rapidly and positively remove oxide scale and sludge without attacking the base metal. The salt bath is heated by immersion tubes, with automatic temperature control up to 950° F. More efficient than acid pickling, for both ferrous and non-ferrous metals . . . for strip, plate, wire or other products.

• write for additional information

DREVER CO.

730 E. VENANGO ST., PHILADELPHIA 34, PA.

W. PENNA., W. N. Y. AND OHIO — H. C. BOSTWICK, 1948 S. MORELAND BLVD., CLEVELAND 22, OHIO

STEELKLAD

outlasts all other brick in open hearth furnaces

SEE PAGE 55

This is STEELKLAD

1. Made by the famous RITEX Process.
2. Jacketed under high pressure in a patented steel shell.

GREFCO

GENERAL REFRACTORIES COMPANY

IN FRONT WALLS, BACKWALLS AND MONKEY WALLS

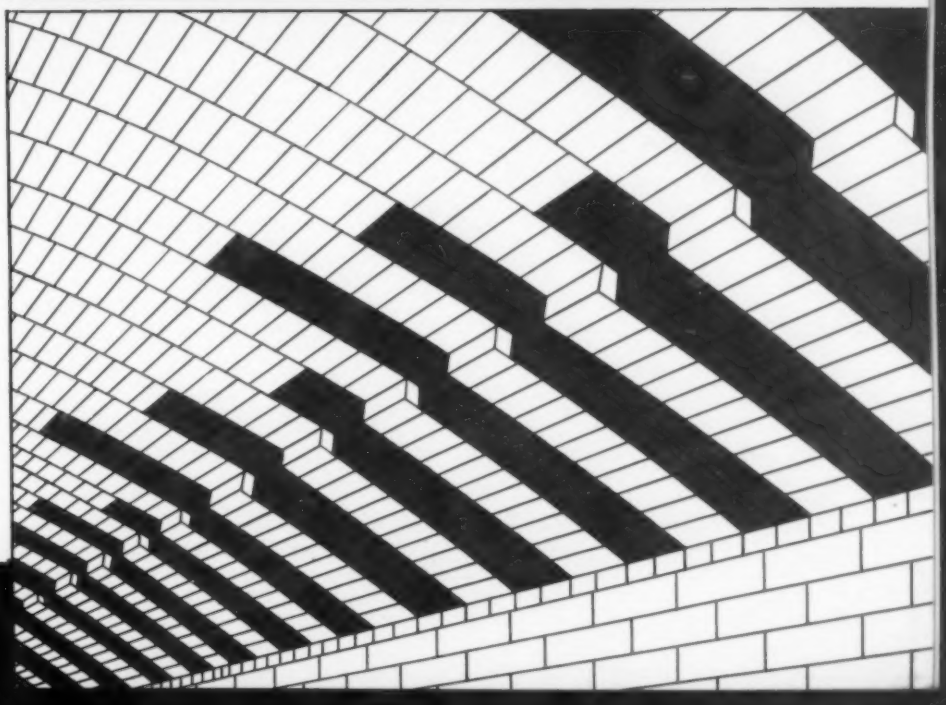
STEELKLAD are the standard of the industry.

FURNACE ENDS

STEELKLAD in Ends last 2-3 roof campaigns.

The New "ZEBRA" Roof

Again STEELKLAD shows the way. In over 80% of "Zebra" roofs, Ritex STEELKLAD are alternated with Silica brick. Users report 25% to 35% increase in roof life.



A Complete

Refractories Service

"YOU BUY 1 BOX . . . OR 10,000 BOXES . . . AT THE SAME LOW FLAT PRICE PER BRUSH!"

BECAUSE WE'VE STANDARDIZED NATIONAL TRADE-MARK CARBON BRUSHES

FOR STEEL MILL EQUIPMENT!

YOU PAY the same low, flat price regardless of how many brushes you buy, providing you buy one box or multiple thereof. You get fast delivery because these brushes are kept in stock in large supply. You get better quality because of manufacturing refinements made possible by mass production economies. You get a brand new package — sturdy, attractive, easy to store and handle.

Why is this possible? Because we have STANDARDIZED "NATIONAL" brushes for popular motors and generators. We have picked the most versatile, the most widely used, the best brushes in the field. We have made them applicable to an even greater number of jobs — made them better in many ways — and we are now making these brushes in quantity. The list of STANDARDIZED steel mill brushes follows:

FOR MILL TYPE MOTORS

NC 20-4800	2¼ x 1½ x ⅝ Grade AX-5	—For GE Type "MD"; West. "MC" & "K"
NC 20-5600	2¼ x 1¾ x ⅝ Grade AX-5	—For GE Type "MD"; West. "MC" & "K"
NC 24-4800	2½ x 1½ x ¾ Grade AX-5	—For West. Type "MC"
NC 24-5600	2¼ x 1¾ x ¾ (⅜-⅜)	—"Plytek" Brush Grade AX-5— For GE Type "MD"
NC 24-6400	2½ x 2 x ¾ Grade 401	—For West. Type "MC" & "K" Also Crocker-Wheeler "EW", "FW" & "SW".

FOR GENERAL PURPOSE D. C. MOTORS AND GENERATORS

NC 12-3202	1¾ x 1 x ⅜ Grade 255	—For West. Type "SK"
NC 12-4001	1¾ x 1¼ x ⅜ Grade 255	—For West. Type "SK"
NC 20-4002	1¾ x 1¼ x ⅝ Grade 255	—For West. Type "SK"
NC 12-5610	2½ x 1¾ x ⅜ Grade SA-35	—For West. Tandem Holders
NC 16-5603	2½ x 1¾ x ½ Grade SA-35	—For West. Tandem Holders
NC 12-4003	2 x 1¼ x ⅜ Grade 255 (15/15 Bevel)	—For GE Type "CD"
NC 16-3205	2 x 1 x ½ Grade 255 (15/15 Bevel)	—For GE Type "CD"
NC 12-4802	2¼ x 1½ x ⅜ Grade SA-35	—For "Toe-to-Toe" Holders
NC 16-4804	2¼ x 1½ x ½ Grade SA-35	—For "Toe-to-Toe" Holders

FOR ELECTRIC WELDERS

NC 16-2001	1¼ x ⅝ x ½ Grade SA-50
NC 16-4801	1½ x 1½ x ½ Grade 255
NC 20-4801	1¾ x 1½ x .618 Grade 255
NC 20-4802	1¾ x 1½ x .618 Grade SA-45

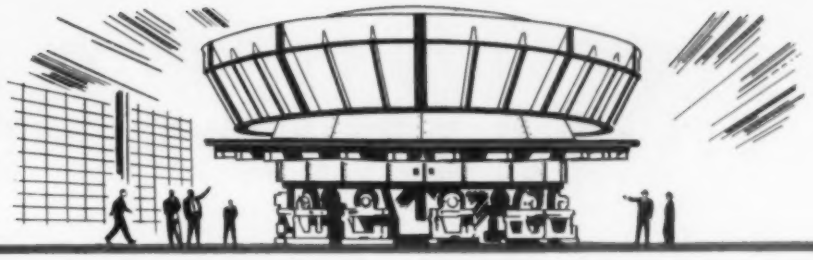
The terms "National", "Plytek" and the Three Pyramids Device are registered trade-marks of

NATIONAL CARBON COMPANY • **Division of Union Carbide and Carbon Corporation**

30 EAST 42ND STREET, NEW YORK 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco • In Canada: National Carbon Limited, Toronto 4

McKee 16
Wind Box
Sintering Machine



POLLOCK

chosen to construct latest sintering plant equipment

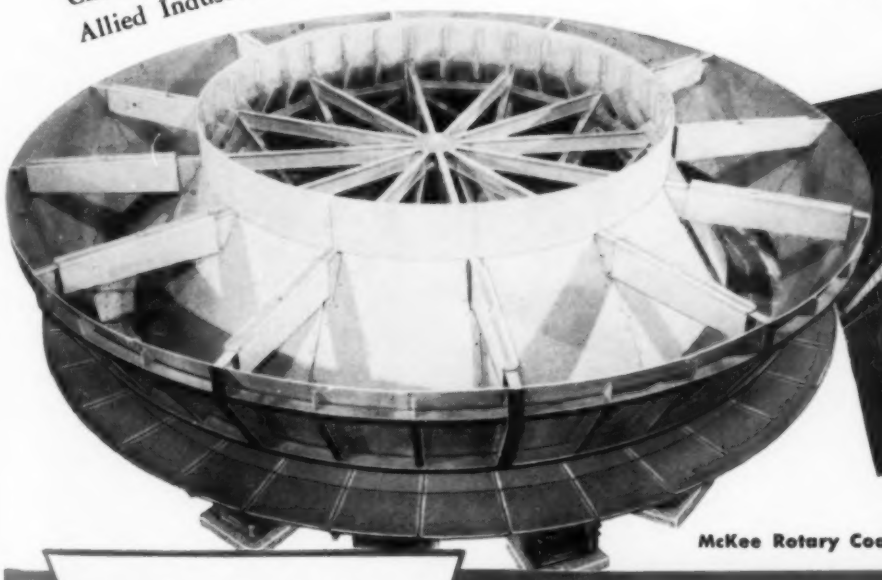
POLLOCK ALSO MAKES . . .

Miscellaneous Welded and Riveted Steel Plate Work for Blast Furnaces and Steel Plants, Oil Refineries, Chemical Plants and Allied Industries.

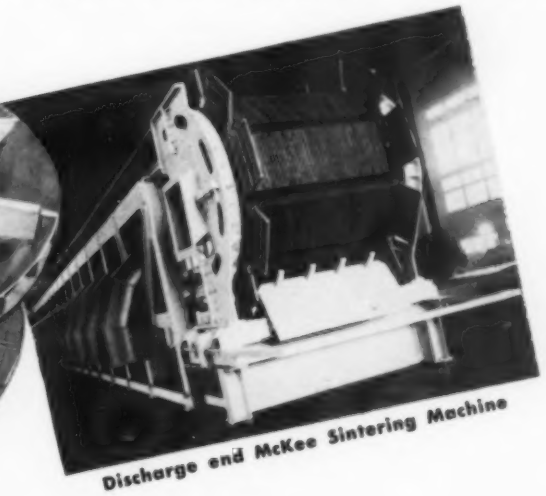
TO construct its newly developed sintering plant equipment, Cleveland's Arthur G. McKee Company chose The William B. Pollock Company, steel plate construction experts since 1863.

This latest sintering machine and rotary cooler were assembled in Pollock's Youngstown, Ohio plant and inspected by the customer and many interested iron and steel operators and engineers while in test operation. Then it was thoroughly match-marked, disassembled, and loaded on 16 railroad cars in such a way as to insure quick and efficient field erection.

Pollock is known the world over for its reliable, efficient heavy plate construction.



McKee Rotary Cooler 48 Ft. 4 In. Diameter



Discharge end McKee Sintering Machine

POLLOCK

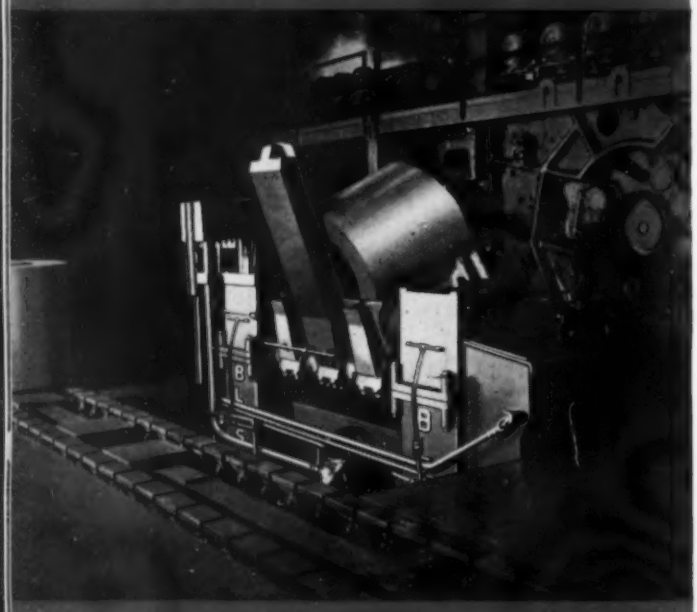
THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN · OHIO
STEEL PLATE CONSTRUCTION · ENGINEERS · FABRICATORS · ERECTORS

BLAST FURNACES · HOT METAL CARS AND LADLES · CINDER AND SLAG CARS · INGOT MOULD CARS · CHARGING BOX CARS · WELDED OPEN HEARTH LADLES

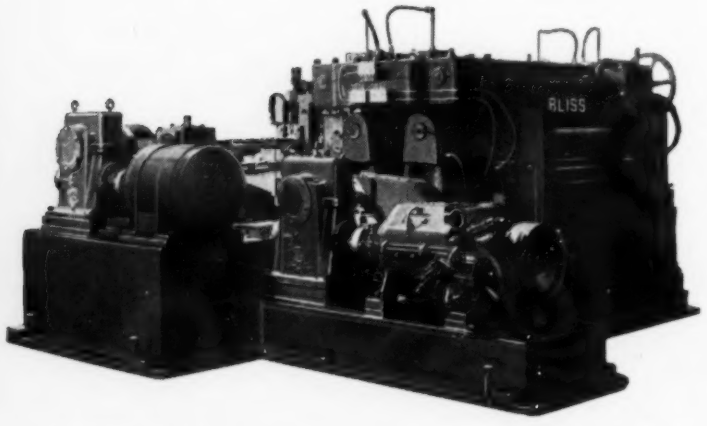
HOW BLISS DESIGNS FOR STEEL, BRASS

PRIMARY METAL PLANTS use hundreds of Bliss special-purpose machines in conjunction with hot and cold reduction mills. In every case, backed by field research with industry's engineers, Bliss has drawn upon its engineering skills to create equipment combining the necessary ruggedness and precision for the job at hand.

Pictured on these pages are typical exam-

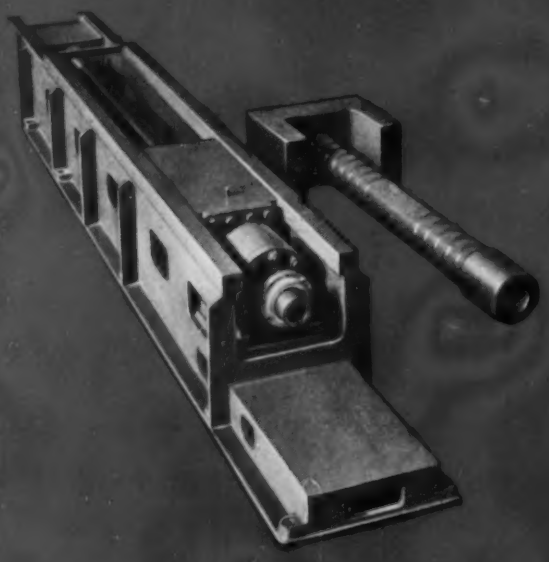


COIL UPENDER strips hot 25,000-pound coils from the Mandrel Coiler, upends and deposits them on a "waffle top," which in turn deposits coils on the moving conveyor strands without damage to coil edges.



13 ROLL BREAKER produces scale-free and inclusion-free product which is suited for final reduction operations.

RUN OUT DELIVERY TABLE specially designed by Bliss has slab sweep-off sections opposite piler. A slab pusher is provided on one side.



ROLL CHANGER WITH SLIDING RAIL permits easy roll removal from the mill and reduces required crane capacity. Balance bar is used to handle work roll assemblies

AUXILIARY EQUIPMENT AND ALUMINUM MILLS

ples of mill accessory equipment designed by Bliss. The complete range is described and illustrated in a new 52-page brochure soon to be published. You can reserve your copy now.

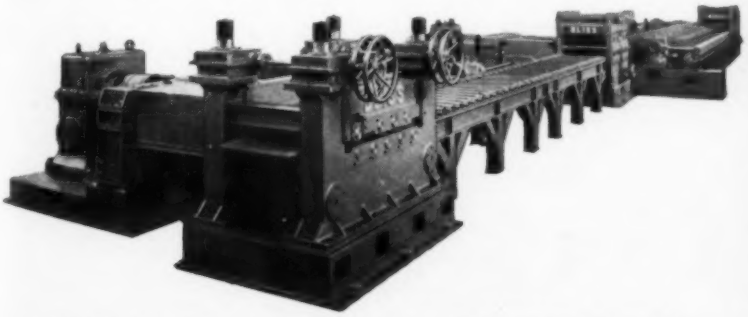
Next time you need auxiliary mill equipment, call in Bliss engineers.

E. W. BLISS COMPANY

General Office: CANTON, OHIO

Rolling Mill Division: SALEM, OHIO

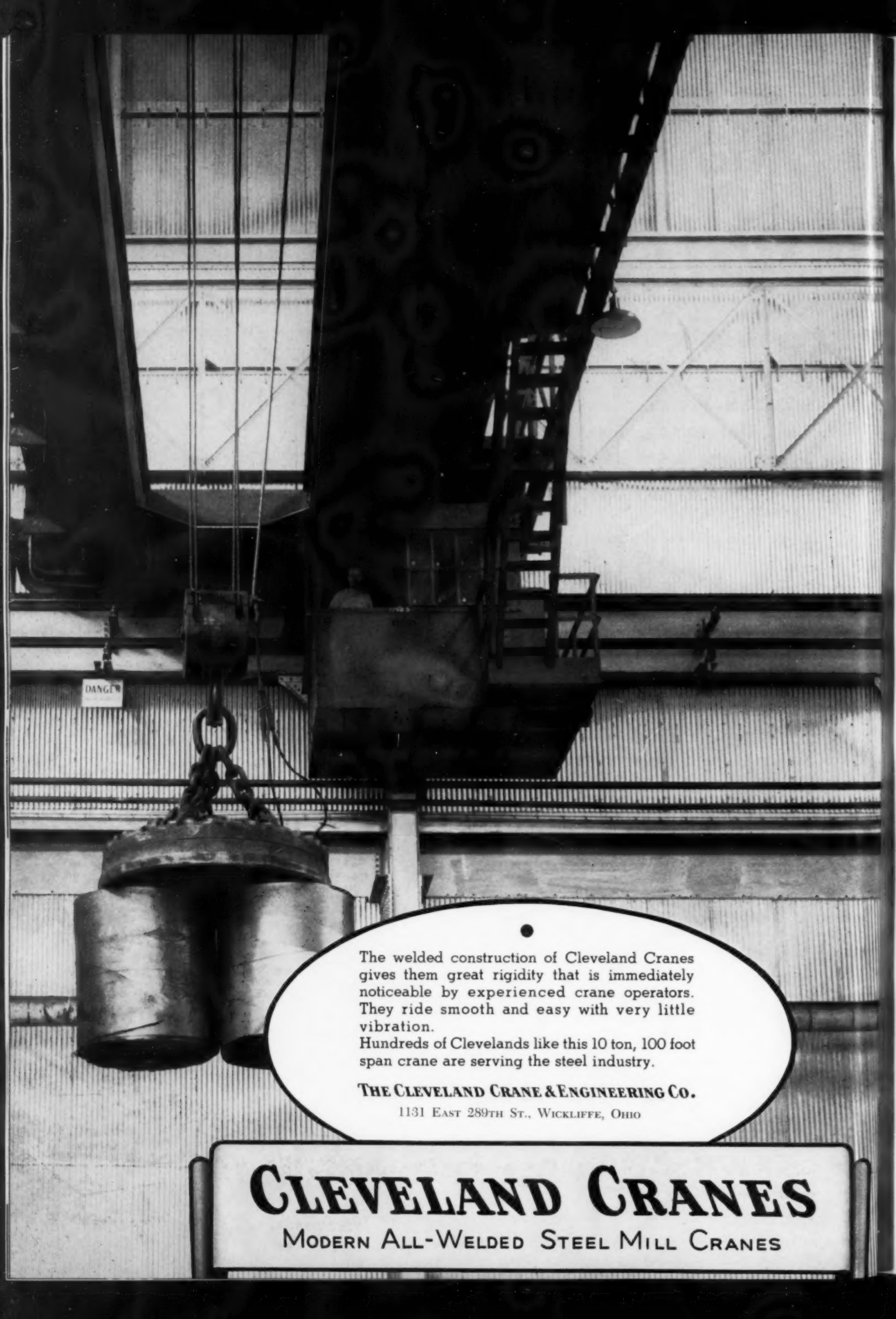
WIDE HORIZONTAL-TYPE BELT WRAPPER is used in conjunction with Tension Reel to coil strip on the fly into tight, uniformly wound coils.



COMBINATION LEVELER AND SLAB MILLER levels the slab, mills one side, turns the bar over and mills the other side. It is used in brass and aluminum mills to prepare metal for final

COIL LIFT AND TURN-AROUND UNIT transfers coils weighing up to 30,000 pounds from one leg of conveyor to another. It operates at either 90° or 180°. Perfect coil edges are retained.

TENSION REEL AND BELT WRAPPER handles 30,000-pound coils. Forced-circulation oil lubrication pump and piping are shown clearly on the typical Bliss gear reduction unit.



The welded construction of Cleveland Cranes gives them great rigidity that is immediately noticeable by experienced crane operators. They ride smooth and easy with very little vibration.
Hundreds of Clevelands like this 10 ton, 100 foot span crane are serving the steel industry.

THE CLEVELAND CRANE & ENGINEERING CO.
1131 EAST 289TH ST., WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

A REPORT from the American Iron and Steel Institute indicates that the industry will spend $1,200,000,000, a record amount, for expansion and improvement in 1951, and probably somewhat more in 1952. The institute now predicts an annual steelmaking capacity of more than 117,500,000 tons by the end of 1952, although we believe this will be revised upward as additional projects develop.

During the seven years between the beginning of 1946 and the end of 1952, the industry will spend somewhat more than $5,000,000,000 (and somewhat more than the total capital investment in the industry in 1946) while adding only 25,600,000 tons of steelmaking capacity. This gives a figure of about $200 per ton, as compared to about $50 per ton for the investment prior to 1946.

▲

THE Treasury Department has allegedly devoted a lot of attention to issuing an "easy-to-read" pamphlet on income tax and to developing an "easy-to-fill-out" tax blank. What we need is a little economy to make it easy to pay. It's hard to believe these days that this country was founded partly to avoid taxation.

▲

AMID rainy snow and a host of dignitaries, ground was broken for the new Fairless Works of United States Steel Company, a project which is being received with mixed emotions. Bucks County farmers, besieged with purchase offers for their farms for real estate developments, are holding at $1500 an acre their land which was valued at $300 an acre two years ago. Prices on houses already built have increased as much as 75 per cent in the past 18 months.

On the other hand, letters to the editors of Philadelphia papers protest the location of the plant in "the last scenic stretch of waterfront on the Delaware." The letter writers fear that the industrial development will blot out historical shrines with which the region abounds.

▲

FIVE years ago, your editor took some ribbing over the closing paragraph of an article prepared in connection with the 1946 AISE spring meeting in Philadelphia. The paragraph, which received considerable publicity in Philadelphia newspapers, said: "Sometime in the not-too-distant future, as the high grade ores of the Great Lakes region play out and benefication requirements increase the cost of the leaner ores, the availability of imported ore by water transportation may make the eastern coast definitely attractive to more steel producers. Philadelphia may return to its status of 1800, when it was the largest iron producing center in America."

We disclaim any ownership of a crystal ball, and we certainly wouldn't want to be guilty of saying "I told you so," but . . . .

▲

FROM Kroehler News: "Bars are something which if you go into too many of, you come out singing a few of, and maybe land behind some of."

▲

THE total payroll of the iron and steel industry in 1950 is estimated by the American Iron and Steel Institute at $2,390,000,000, an all-time record. Hourly payments to wage earners averaged $1.746 for the year, four cents more than in 1949 and more than twice the 1940 rate. The average work week was 39 hours.

During the month of December the hourly wage payments rose to $1.96 because of the new wage agreements effective December 1 and various year-end adjustments in vacation pay allowances.

▲

PROFESSOR H. M. Jones of Harvard says, "Ours is an age which is proud of machines that think, and suspicious of any man who tries to."

▲

EMPLOYMENT in the iron and steel industry now stands at approximately 657,000, the highest on record except one wartime month in 1942. The American Iron and Steel Institute also reports that steelworkers are holding onto their jobs more consistently than ever before. During the first eight months of 1950 the steel industry experienced a separation rate of only 1.6 for each 100 employees, compared with 3.1 for all manufacturing industries. This comparison is more favorable for the steel industry than the relationship prevailing in 1946-49.

▲

CHARLES Schwab, in one of his inimitable speeches, said: "Everything that you and I buy is 95 per cent wages. People speak of cost of labor and cost of material. What we call material is nothing but wages paid elsewhere." Questioned by W. Trinks, following the speech, as to whether he forgot about taxes, Mr. Schwab said: "Taxes are only wages paid in Washington."

And yet the fallacy about high wages and low prices lingers on.

▲

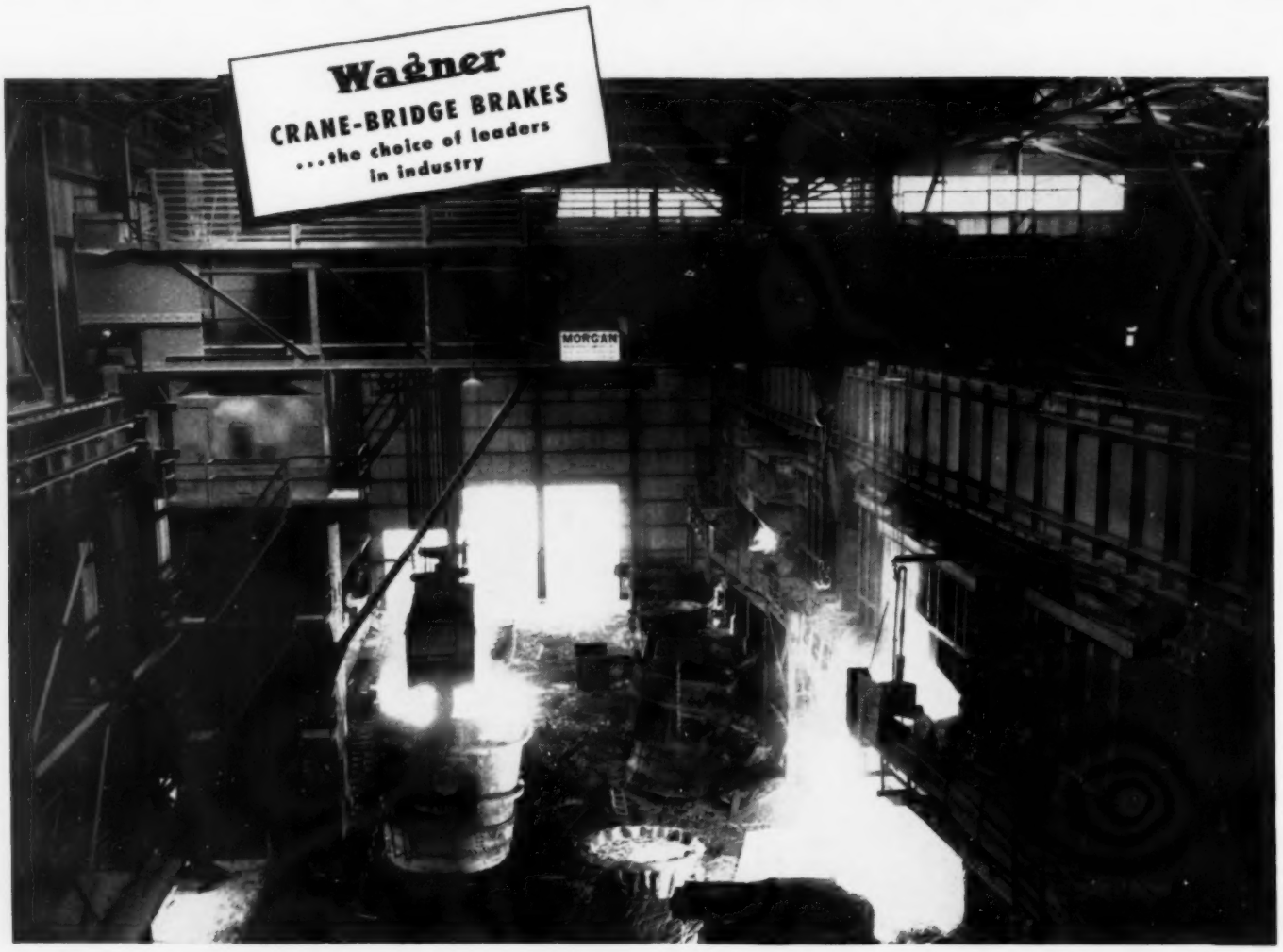
SPEAKING of wages and prices, what has become of the "freezes" so bravely announced a few weeks ago? Between exceptions, exemptions, and allowances, already made and to come, they look like another bit of spineless log-rolling, along with failure to reduce non-defense spending or to tighten up money and credit. Washington preaches against inflation but is actually helping it along.

▲

THERE are a lot of self-made men that might have done better by letting out the contract.

▲

DURING 1950, 340,000 homes burned, with a loss of life of 11,000, and 90 per cent of this waste is attributed to carelessness.



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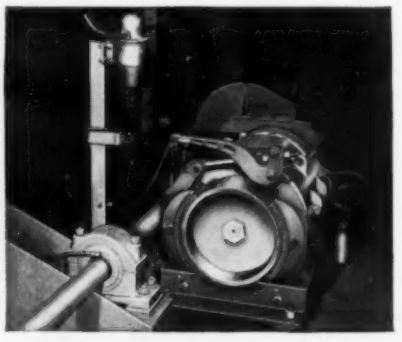

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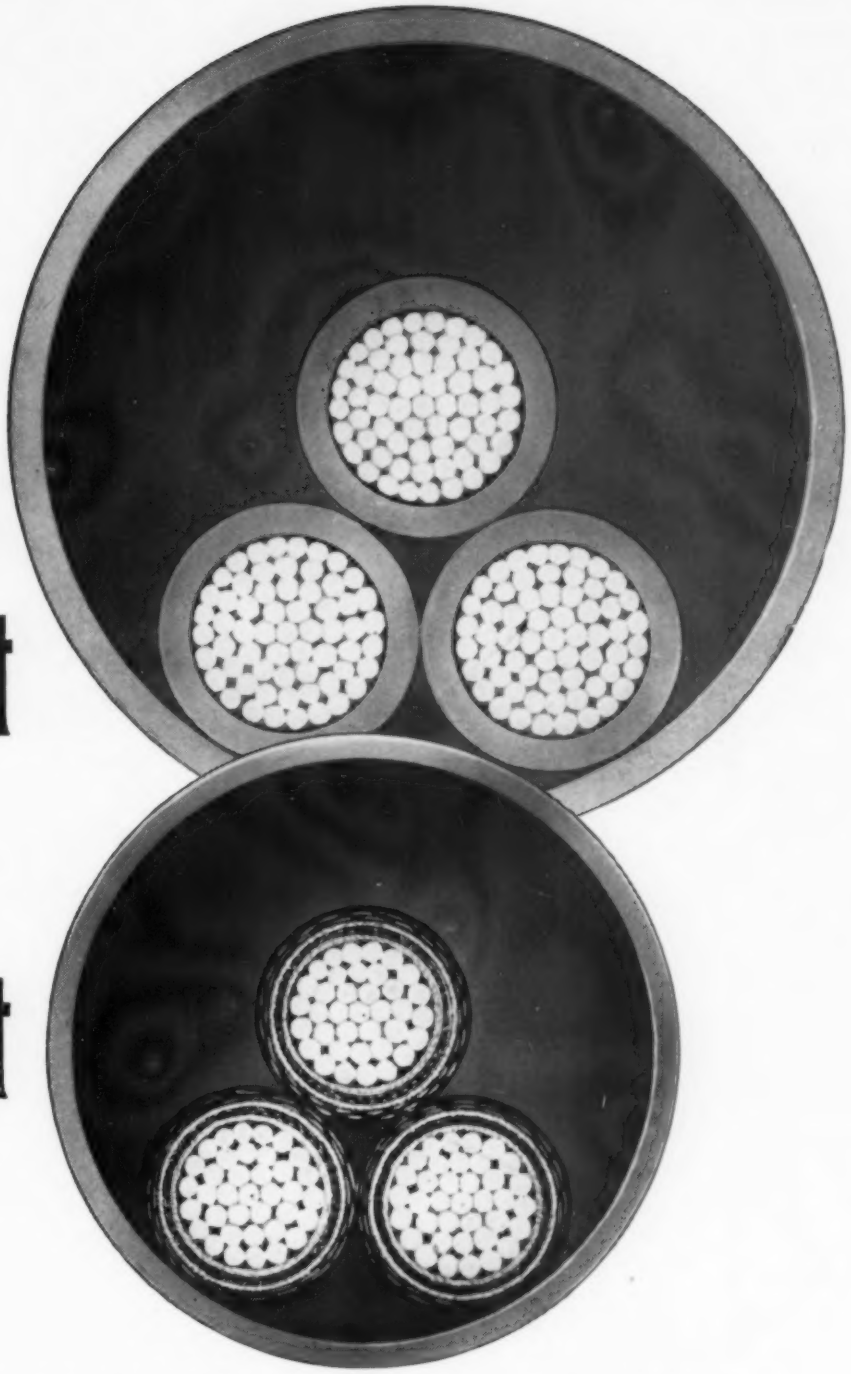

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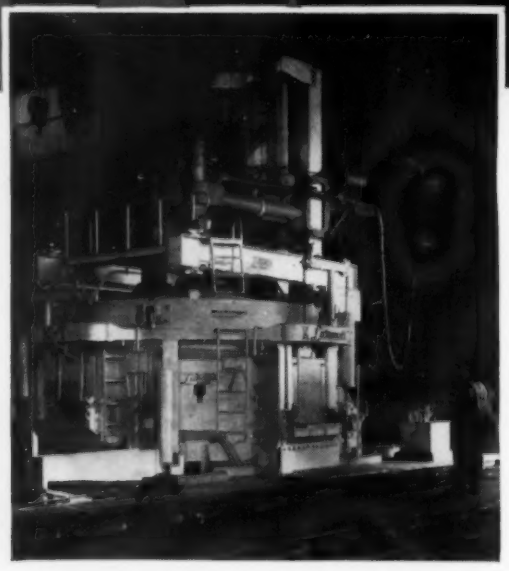

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ECONOMICS OF A 500-TON OPEN HEARTH FURNACE

. . . . the large open hearth has proved itself so economical that a number of such units are scheduled for construction . . . .

By W. W. KOMPART
Combustion and Hydraulic Engineer
Weirton Steel Co.
Weirton, W. Va.

▲ THE furnace discussed in this paper is one of a 12-furnace open hearth shop, in which all furnaces are stationary. Five of the 12 furnaces are tapping approximately 280 tons each, five are tapping approximately 425 tons each, one 400-ton furnace is tapping approximately 480 tons, and this particular furnace is tapping approximately 550 tons. The maximum size heat tapped from this furnace has been 601 tons. The furnace utilizes 65 per cent blown metal and 35 per cent scrap to make a product which is approximately 50 per cent tin plate and 50 per cent deep-drawn steel.

In the early part of 1949, the original No. 1 open hearth furnace was producing approximately 200 tons per heat. This furnace, with its auxiliaries, was due to have a complete rebuild which included the removal of a 600-hp waste heat boiler that had served its useful purpose. As stated previously, we already had one 400-ton stationary open hearth furnace, and from the experience of operating this furnace we could see no difficulties in the operation of a 500-ton furnace. It was therefore decided that in the complete rebuilding of No. 1 furnace, it should be enlarged to a 500-ton furnace. Another factor in making this decision was the possibility of increased steel production at reduced cost. No. 1 furnace was located adjacent to the two bessemers which would permit the rapid handling of blown metal between the bessemers and this furnace, thereby materially increasing the production of the furnace. As our bessemers are of 35-ton capacity and hot metal to this furnace is approximately 700,000 lb per heat, the movement of this metal to an adjacent furnace was considered an economical arrangement.

This furnace was rebuilt with the following construction and dimensions: The bottom of the furnace rests on 15-in. I-beams, above which is a ¾-in. steel plate. Above the steel plate there was installed 2 in. of ganister and luminite cement, the mixture being made up of three parts ganister and one part luminite. At the center of the furnace there is a 6-in. course of first-quality clay brick. This thickness of clay brick increases from the center of the furnace toward each end, reaching a maximum thickness of 12 in. Above this brick course there is 13½ in. of chrome brick and above the chrome brick there is a minimum of 13 in. of a rammed mix. The back wall is of the sloping type and is made up of courses of chrome, unburned basic brick and a ramming mix to a thickness of approximately 3 ft. Basic ends were installed on the furnace extending from the port roof to the bottom of the slag pocket. The basic brick extended approximately 13 ft over the port section. The balance of the roof was made up of 15 in. silica brick with 18-in. ribs which are spaced every five courses of roof over the straight section of the roof. The span of the roof is 25 ft 3 in. out to out of the skewback. The roof has a radius of 22 ft 7⅛-in. with a 3 ft rise. The overall length of the furnace is 96 ft 6-in. The sloped section of the roof has a slope of 14 in. in 20 ft from the straight section of the port. The straight section of the main roof is approximately 28 ft. The buckstays on the furnace are of laminated construction which is standard in this shop. The skewback which is supported by the buckstays is 10 ft x 3¾ in. from the steel floor plate. The sill line is 6 ft 7½ in. from the floor plate. The depth of bath is 3 ft 11 in. from the sill line to the top of the rammed mix material. The length of the bath at the sill line is 59 ft 4 in. and the width is 20 ft. Seven doors are used on this furnace, each having an opening of 4 ft 4 in. x 4 ft. 4 in. The distance from the port roof to the slag pocket floor is 36 ft 10¾ in. A single uptake of 9 ft 3 in. x 19 ft is used at either end of the furnace. The slag pocket dimensions are 23 ft 8 in. long x 19 ft wide x 14 ft 6½ in. deep. A single fantail connects the slag pocket with a single checker chamber. This fantail is 10 ft 8⅜ in. long from the inside of the nose to the wall of the checker chamber. The checker chambers were originally the conventional gas and air checkers. In constructing this furnace it was decided to use only one checker chamber, eliminating the walls between the old air and gas checkers. The checker chambers were deepened to provide a 5 ft 9 in. opening under the supporting arches due to the possible economies in cleaning under the checker chambers. The ability to readily clean under the checkers reduces the time required for cleaning and provides better draft conditions. On top of these arches is a 12 in. course of rider brick, and above the rider brick as originally installed there were

Figure 1 — Roof life on the furnace has been about 50 per cent over the shop average.

26 courses of 6 in. checker brick, giving a total height of 13 ft. After the first campaign it was found unnecessary to have this height of checker brick, and in addition, the blowing of the checkers indicated that this height should be reduced. We therefore took off the top 3 ft of the checker brick, leaving a height of 10 ft. The checker chamber is 31 ft 9½ in. long x 25 ft 6 in. wide x 23 ft 11 in. high as measured from the floor of the checker to the underside of the roof. The roof of the checker is of the suspended type. The main section of the roof is 9 in. thick, with approximately 12 ft from the slag pocket and 12 in. thick. Two and one-half inches of insulation is used on the roof and side walls. The width of the checker necessitated the construction of two exit flues, one 10 ft 5½ in. high x 8 ft wide, and one 10 ft 7 in. high x 5 ft 3 in. wide. These two flues merge into one flue at the base of the stack with an opening of 11 ft 1 in. x 11 ft 7½ in. The size of these flues was largely influenced by the possible economies obtained in the rapid cleaning of the flues. Flue dust is removed by means of a vacuum system. The construction of checkers and flues has proven very satisfactory, as it has provided for ample checker volume, low draft loss, less time required for cleaning and ample space to collect flue dust—all of these factors tending to give greater economy.

The two stacks used on this furnace have a 16 ft diameter base. Checkers within the stack are made up of six courses of 18 x 6 x 3 in. brick above the arches, above which there are two courses of 10½ x 6 x 3 in. brick topped with 24 courses of 13½ x 6 x 2½ in. brick. The brick are all laid as straight flues. No checker brick are used in the flues. Two fans, alternately used for forced air and induced draft, are incorporated with the stacks, and operate under automatic furnace pressure control. No automatic reversing or fuel air ratio control is used.

This furnace was first put into operation on September 12, 1949, requiring approximately 3½ months to rebuild. On the first day of operation, this furnace produced two heats, averaging 530 tons per heat. As stated previously, this furnace has produced a maximum of 601 tons per heat.

At the time the furnace was put into operation, the ladles were of 280-ton capacity and it was necessary to produce heats not greater than 550 tons. Since that time our ladle capacities have been increased whereby it is possible to tap 300 tons per ladle. Our present ladles are 15 ft 10⅜ in. high x 10 ft 11¼ in. wide x 13 ft 11¾ in. long with 5 ft 5⅝ in. radius on ends. The first run of the furnace had 166 heats on the roof, and the second run gave 193 heats. The third run gave 123 heats at which time the roof buckled in the front section due to punching the roof with scrap. This roof life is approximately 50 per cent above shop average and has justified the economies expected from a large furnace and this type of construction.

The percentage analysis of the hot metal is approximately as follows:

1.5	carbon
0.20	manganese
0.01 to 0.02	silica
0.3	phosphorus
0.34	sulphur

The 35 per cent scrap is all light scrap. The charging time from the time of charging to the time that all scrap metal is in the furnace varies from 4½ to 6 hours.

We believe that the installation of basic ends in this furnace has definitely shown economies over the former two uptakes of silica construction.

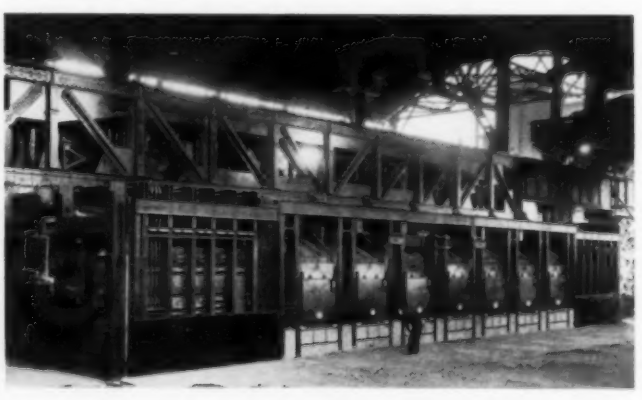
After the first run of 166 heats, a small amount of work was done on the basic port roof. In addition, a small patch was required on the end walls. No basic brick below floor level was replaced. On the second roof campaign, the basic brick was replaced in the ends above the floor and also the port arches. After the third run, no basic brick was replaced above the floor except a small part of the port roof at one end of the furnace. At the end of each roof campaign, slag is removed from the slag pocket, checkers blown and flues cleaned. Slag removed is much less than formerly and can be readily removed by a high lift crawler tractor. Openings are provided for the high lift crawler tractor to enter the slag pocket.

To date we attribute a reduction of approximately 25 per cent in rebuilding costs per ton of steel produced to the use of basic brick construction and size of furnace. At the end of our first campaign when the furnace was taken off, the necessary repairs were made, a new roof installed, the flues, checkers and slag pockets cleaned and the furnace put back into operation after 74 hours elapsed time. The front wall construction is all basic and has a life of 80 to 90 heats. After the second run, 100 hours were required as elapsed time to again put the furnace back into operation. After the third run, the furnace was down for a period of 63 hours and 55 minutes.

As can be noted from the previous statement on charging time, we are of the opinion that the future maximum economies to be obtained from this furnace lie in some method yet to be developed whereby the time of charging may be reduced. The charging boxes used on the furnace are of 42 cu ft capacity and will handle a maximum of 7500 lb per box. The number of boxes charged per heat varies from a minimum of 150 to a maximum of 300 boxes.

We find that the use of oxygen at the burner to decrease our scrap melting time is of no particular advantage due to the length of time required to get scrap into the furnace. Time gained through the use of oxygen is only lost in charging. Therefore, until a bet-

Figure 2 — The furnace is an end unit located adjacent to the bessemer.



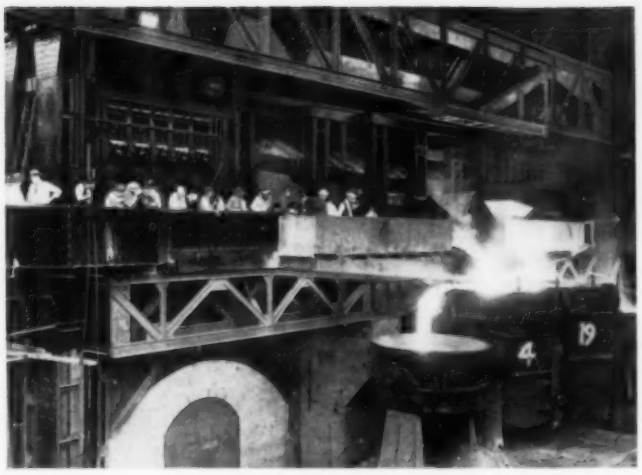


Figure 3 — Larger ladles and higher capacity cranes were installed on the charging floor side.

ter and faster method is developed for charging, we probably will not use oxygen in any large quantities for enriching our fuel. We do use oxygen in the bath which we believe to be of distinct advantage in reducing the tap-to-tap time of heats. The time of heats is approximately 11-13 hours. This furnace, as well as six other furnaces in our shop, is tapped into two ladles at the same time by means of a bifurcated pouring spout. In order to balance the molten metal going into each ladle, we have provided a divider which is manually operated to permit a greater or lesser flow of molten metal to either of the two ladles. This practice has been standard in our shop for many years, and has given us no trouble. One stopper rod is used for each ladle. Skulls present no serious problem when properly handled.

Normal shop fuel consumption when using oil or tar is approximately 22 gallons per ton. On this particular furnace, our fuel practice is approximately 14 to 16 gallons per ton. We believe this reduction in fuel is partially due to the size of the furnace and heats, type of construction (including basic ends), large checkers and flues, use of higher preheated air for combustion, and sufficient draft.

In the design of this furnace our aim was to provide more available fuel, air and draft than would ever be used in the operation of the furnace. We therefore provided for a maximum fuel input of 15 gpm of which about a maximum of 12 gpm has been used with a normal 10 gpm. The air supply is approximately 30,000 cfm, and draft at the base of the checkers is a maximum of 2 in. With this combination we have been able to operate more economically when the checkers and flues become dirty and the furnace would have a normal tendency to slow up.

DISCUSSION

PRESENTED BY

L. J. GOULD, Chief Engineer of Construction, Bethlehem Steel Co., Bethlehem, Pa.

W. W. KOMPART, Combustion and Hydraulic Engineer, Weirton Steel Co., Weirton, W. Va.

F. C. McGOUGH, Combustion Engineer, Republic Steel Corp., Youngstown, Ohio.

L. J. Gould: A good many of the engineers of the steel industry have been discussing the possible maximum size of the furnace, for those who do not use blown metal. I would like to ask the speaker if he has any limitations in his mind on the maximum length of time to make the heat, providing another practice is used? In other words, is the 600-ton furnace based on the melting time or what?

W. W. Kompart: It would be rather hard to say here whether you should build a large furnace, if you do not have blown metal, except for our previous practice as mentioned. We have a 400-ton stationary furnace which has been in operation for approximately 22 years. This furnace was operated through the depression and we did not have blown metal, but used a large percentage of scrap, and our tonnage rate and economy on the furnace was in line with the smaller furnaces. In fact, it was better than the smaller furnaces. Considering our experience, I believe that a larger furnace is a lot more economical on refractories than a small furnace, especially at the driving rates that are being made today.

F. C. McGough: Mr. Kompart indicated that he did not make installations of reversal or combustion control. I would like to know if there is any program in mind for such controls on the furnace and his opinion on the relative value of the various controls.

W. W. Kompart: Our shop, for years probably, ran with the smallest amount of automatic control in the country, or as small, let us say. We are getting a little more control conscious and on this furnace, which to a great extent was an experimental furnace with us, we did not go into full control. We did put on a furnace pressure control. We did not put on a full air-fuel ratio and we did not put on reversing control. We do feel that it may be possible to get better economies or maybe a little longer life by the use of a roof temperature control. Except from a standpoint of convenience to the operator, however, we do not feel that reversing control is going to show any great economy.

At the present time we lose more time in getting our complete scrap charge into the furnace than we can save by any automatic features. If we could charge efficiently, oxygen could be used with the fuel to melt scrap faster and thereby save considerable time. We have demonstrated that the use of oxygen with the fuel will reduce the time of melting-down. Due to charging, this saving in time is lost again by having the furnace lay idle waiting for scrap.

In short, our problem is to efficiently charge scrap so that any saving due to oxygen with the fuel and automatic controls can be realized.

We do believe in roof temperature control; however, in some instances roofs have been burned and the roof temperature control has been used as an alibi. It is possible to burn a roof in other locations than the area where the control is located. We are therefore going into controls slowly and trying to evaluate the advantages as each control is installed.

Construction and Operation of TONNAGE OXYGEN PLANTS

By MARTIN J. CONWAY
Steel Industry Consultant
Stacey Brothers Gas Construction Co.

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▲ LOW cost oxygen produced in large quantities as an industrial raw material has received noticeable publicity during the past few years and a number of articles on this subject are available in technical and trade journals. Most of these published articles deal with the economics of the application of 90-95 per cent purity oxygen in the basic industries together with fairly comprehensive information on process cycles.

The production and industrial application of tonnage oxygen in Germany and elsewhere prior to the war was not paralleled in the United States. In fact, until the upsurge in interest which has taken place during the past few years, cheap oxygen was a dream in the minds of a very few people. The reason for this is obvious. Most people have been accustomed to think in terms of the price for which oxygen is sold by leading producers of high purity material. These prices bear no necessary relationship to the cost of producing this oxygen, since the costs of distribution and other so-called services supplied by the oxygen producers are necessarily included. Consequently, there has been a lack of incentive to lower the cost of the oxygen itself or to replace the existing small commercial plants with more efficient larger units.

According to recently published figures, there are some 232 producing plants scattered throughout 37 states. These plants sell oxygen in two forms, first as a compressed gas in cylinders where the high pressure necessitates shipping seven pounds of container for every pound of oxygen. The second way of transferring oxygen from the plant to the consumer is in liquefied form and is most suitable for large users. While the shipping charges by this latter method are somewhat less, the expense of liquefying the product, allowing for losses in transport, and finally controlling its release at the consumer's plant, are not inconsiderable.

There are many so-called cycles for the liquefaction and rectification of air and the number of cycles which can be conceived is almost infinite. Hundreds of cycles have been analyzed by the methods of thermodynamics in search of more efficient combinations, and there are in all some eleven principal independent variables which must be taken into account in the engineering design of a process based on any of these cycles. When the number of physical variables are combined with the purely engineering electives, the type and varieties of plants which can be engineered for the liquefaction and distillation of air are very great indeed.

The development of efficient cycles for the production of oxygen in the range of 90 to 98 per cent purity in the last five years has been one of the outstanding engineering achievements. From the basic process and equipment devised to provide the armed forces in World War II with light weight portable units which were free from earlier requirements of chemical treatment of the air and of the employment of refrigerants, there grew the present large scale units which are exemplified by installations such as the plant in Winnie, Texas. This plan is producing oxygen of 90-95 per cent purity at a new oxygen rate of 175 tons per day and this type of plant and oxygen production cycle has been taken as the basis for the following discussion.

One of the outstanding features of these plants is that they operate on a cycle that is entirely self-contained. Except for cooling water and a source of power (electricity, steam or fuel gas), nothing is required for the operation other than the air that is processed.

There is no longer a need to use chemicals for air treatment or to use refrigerants. This self-contained feature is an assurance of continuous operation of the plant in any location.

It might be expected that a plant containing these highly desirable features would be handicapped by excessively high initial cost and operating costs. Exactly the opposite is true. Because no portion of the air is compressed above 100 psi, the initial costs, considering the expensive materials which must be used at the very low operating temperatures, are moderate and the unit costs of the oxygen are far below any previously encountered. These costs vary, of course, with the size of the plant and the costs of utilities.

PROCESS DESCRIPTION

Most simply expressed, the production of oxygen from air is by liquefaction of the air and fractionating of the liquefied air into two portions, one of which is principally nitrogen. The diluents of the oxygen stream, in a plant producing 95 per cent oxygen, are nitrogen, argon, xenon, krypton, and also carbon dioxide and

water in the same concentrations as in the compressed air entering the system.

The diluents of the nitrogen stream are oxygen, argon, hydrogen, helium, and neon, and again carbon dioxide and water. The oxygen content of the nitrogen stream depends on the oxygen recovery, which in turn, depends on the oxygen purity. When the oxygen purity is 95 per cent, the nitrogen stream purity is at least 95 per cent and an increased oxygen purity will result in lowered nitrogen purity.

The fractionation of the liquid air presents no unusual process problem. There are practical and mechanical problems introduced by the necessity of operating in the neighborhood of -300 F. Low cost refrigeration is required and the air must be freed of those impurities which would be solid at liquid air temperature. Minimum refrigeration requirements result from extensive heat exchange between the air and the products.

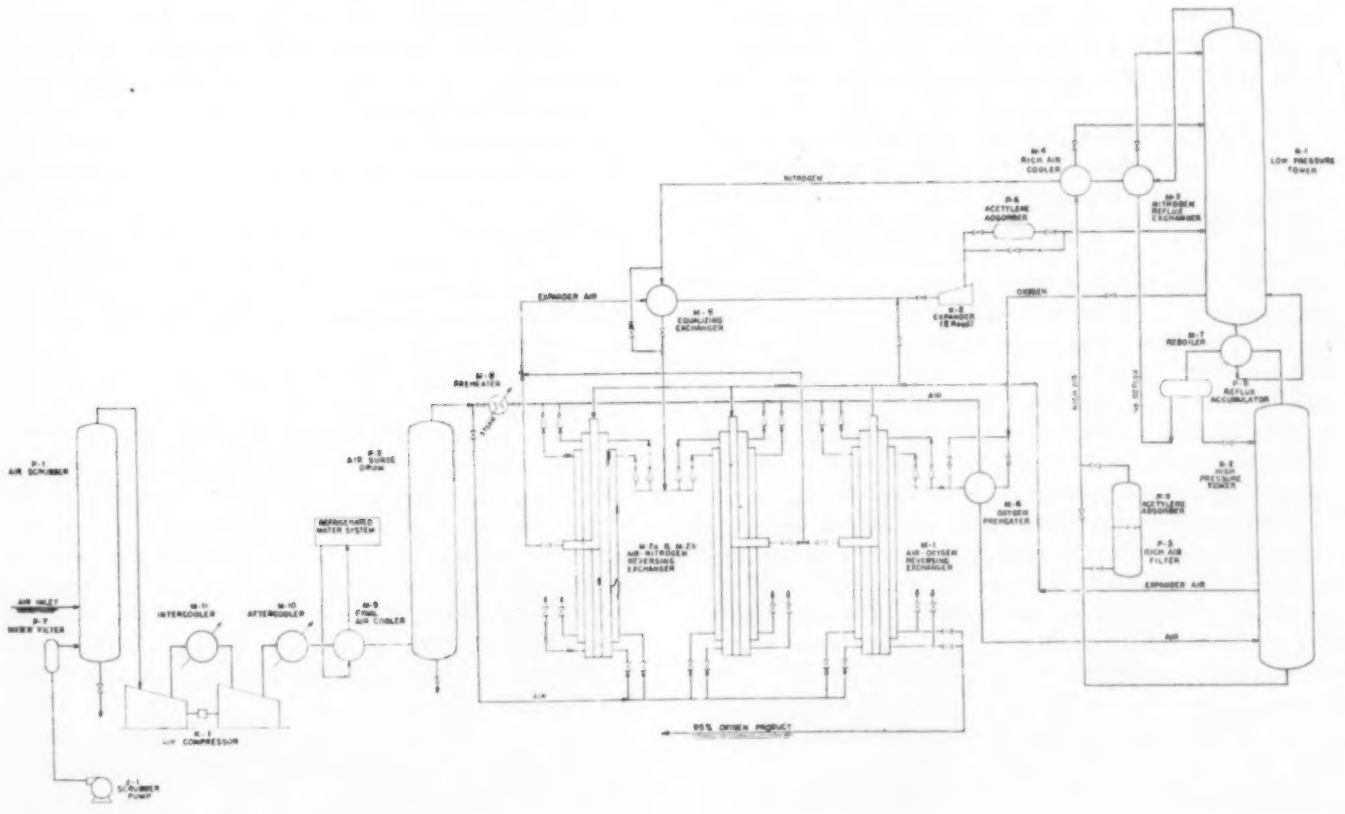
Refrigeration is obtained by approximately isentropic expansion of a portion of the air through an expansion engine rather, than the isenthalpic (adiabatic) expansion of air through a throttling valve. Because the air does work when passing through the expansion engine, its initial pressure does not need to be as high for a chosen temperature drop as it would be if expanded through a valve. Thus, for a terminal condition of -305 F and 4 psig, and an inlet temperature of -220 F the inlet pressure for an isentropic expansion is about 75 psig versus 500 psig for an isenthalpic expansion.

The major impurities in atmospheric air which interfere with the process are dust, water, carbon dioxide, and hydrocarbons. Dust is removed by standard filters on the compressor inlets and by water scrubbers when required. Water, carbon dioxide, and hydrocarbons are almost completely removed from the air as it is cooled in the reversing exchangers by indirect heat exchange with the products. At definite intervals, the air and products reverse sides in the exchanger so that the latter may evaporate and carry away the impurities removed from the former. This reversal is conducted automatically and continually, thus permitting the continuous feeding of almost pure air to the fractionating equipment.

Two complications enter into the simple picture just presented of the reversing exchanger. The first is that air at high pressure has a slightly higher specific heat than the products at low pressure. This results in an increase of temperature difference from the warm end to the cold end of the reversing exchanger. With a practicable temperature difference at the warm end (say 8 F) the temperature difference at the cold end will be so great (25-30 F) that the cold gas cannot evaporate the precipitated impurities. The second complication is that the air feed to the expander must not only be free of impurities but also must be warm enough to avoid liquefaction of air within the expander. Fortunately, there is a single solution to these two problems.

To allow for the higher specific heat of the air, that portion of the cold air which is to go to the expander is recycled part way through the reversing exchanger in a non-reversing passage, and in the same direction as the cold gas. This reheats the air before its entrance to the expander. The reheated air adjusts, by indirect heat exchange, the temperature of the nitrogen entering the reversing exchanger to permit obtaining the correct

Figure 1 — Process flow diagram for large tonnage oxygen plant.



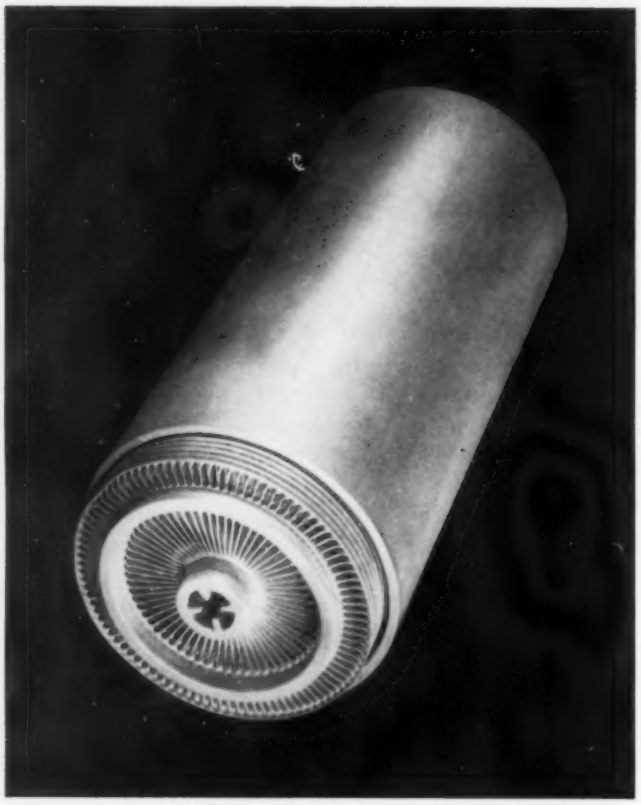


Figure 2 — Illustration shows a three-stream reversing exchanger tube with stamped braised fins.

cold end temperature difference. The oxygen temperature is also adjusted by this cold air.

The characteristics of the precipitated impurities are such that the cycle stream need not pass through the entire exchanger. If it were permitted to traverse the entire length, it would lower the temperature difference in the warm end of the exchanger without yielding a compensating advantage. Therefore, it is withdrawn from the exchanger after it has served its useful purpose.

The fractionation is carried on in two steps in order to obtain the maximum recovery of oxygen. In a single tower system, it is normally possible to obtain only pure oxygen or pure nitrogen; in either case, the yield of the pure material is low. With the double tower system, pure nitrogen and rich air, (oxygen content 38-42 per cent), are obtained from the high pressure tower as liquids; these streams plus the expanded air are processed in the low pressure tower to yield the final products as gases. By heat exchange between the two towers, the heat to be removed from the high pressure tower to liquefy its products is transferred to the low pressure tower to vaporize its products.

There are some additional precautions to be taken because of impurities present in the air. Although most of the carbon dioxide is removed from the air in the reversing exchangers, a small quantity remains. This is due to the vapor pressure of carbon dioxide and also to some mechanical entrainment of solid CO_2. Therefore, filters are provided in the rich air line. These filters are in sets of two so that one may be operated while the other is being freed of carbon dioxide.

Acetylene also requires special consideration as it is not removed in sufficient quantities in the reversing exchanger to prevent a dangerous accumulation in the low pressure tower liquid oxygen. It is dangerous because it tends to detonate at those points where liquid oxygen evaporates from it. The resulting explosions are usually intensive but quite local; they cause sufficient damage in a restricted area to result in the shutdown of the plant. To prevent accumulations of acetylene, either the product oxygen stream must be separately vaporized in a product evaporator under conditions controlled to result in a remainder of a small quantity of liquid oxygen which will act as a carrier of the acetylene, or the acetylene must be absorbed from the rich air and from the expanded air going to the low pressure tower.

The nitrogen and oxygen product streams, after leaving the low pressure tower, pass through the heat exchange system and leave the plant. The nitrogen leaves at atmospheric pressure and the oxygen at about 2 psig, primarily because of the pressure drop through the low pressure tower. While advantage must be taken of the higher oxygen pressure to reduce equipment sizes, it is felt desirable to maintain the discharge pressure at about 2 psig to prevent the infiltration of air.

DESIGN PROBLEMS AND MECHANICAL FEATURES

General—Materials and equipment, plant layout, and detail design, all of these must be chosen to result in a low air requirement at low pressure which results in low power consumption and a reasonable plant cost. Minimum possible loss of refrigeration involves many problems in equipment arrangement and insulation. The application of new, and even of some well-established materials for the low temperature level involved, adds many more problems on allowable stresses and on the working and welding of parts. There is nothing new in the fractionation of liquid air, but the development of satisfactory materials and equipment to do this economically on a large scale has challenged the ingenuity of the engineering profession.

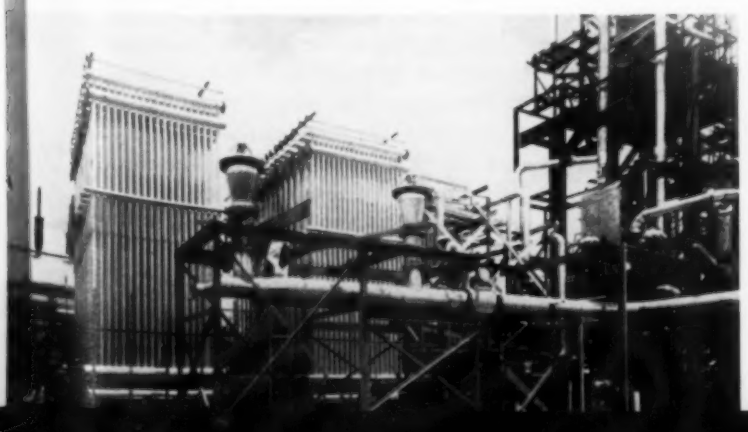
The equipment used in the production of oxygen by fractionation of air at low temperatures necessarily has many unusual and unique features. A considerable amount of what may be classed as standard equipment has modifications as to its constructions or application, the proper incorporation of which are as essential as correct sizing of the equipment itself for the successful operation of the plant.

Air compression—The first operation in the production of oxygen is to compress air to between 85 and 95 psig, the particular pressure used depending on the capacity of the plant. Two stage reciprocating compressors are preferred on plants up to 45 tons per day oxygen capacity. Although a centrifugal type compressor could be used for capacities below 45 tons per day, its overall efficiency in the small sizes is so low that it is usually not an economical installation. The ordinary air compressor drive for these small plants is an electric motor. Above 45 tons per day capacity, the centrifugal compressor efficiency increases to better than 70 per cent, making it the more economical installation, particularly when direct-coupled with a steam turbine for drive. The direct-coupled turbine also provides for

capacity variation in the compressor, with minimum power consumption, by variation of speed. In sections of the country, such as the Southwest, where natural gas is plentiful, gas engine driven reciprocating compressors, although requiring a higher initial investment, are used in all sizes of plants and show as much as 20 per cent less total annual operating cost. Lubrication in any type of compressor must be such that no oil is carried over into the compressed air stream. On centrifugal machines, shaft seals are required to prevent bearing oil carry-over. On reciprocating machines, outboard bearings are provided on each end of the cylinders as well as shaft seals, while lubrication of the piston rings is at present affected by water injected into the suction of each stage. Depending on local water conditions, provision must be made so that the "ph" of the water in the lubricating system can be controlled by chemical treatment, so that corrosion or deposits in the compressors and connecting piping is prevented.

Air cleaning and cooling—The air, either before or after compression, is scrubbed, to remove dirt and dust particles, except for small plants in clean locations, where conventional dry type filters are adequate. The scrubber is placed ahead of centrifugal compressors, whereas it is preferable to place the scrubber after reciprocating machines. The wet cyclone type of scrubber is used in either case and will remove better than 95 per cent of all dust and dirt particles down to about 2 microns in size. The scrubber itself is a vertical cylindrical tower of carbon steel with air introduced through a rectangular tangential nozzle near the bottom. The air takes a spiral path up through the vessel, making several complete revolutions through water sprayed from a central pipe in the lower third of the vessel and finally leaving the vessel through the top. The central pipe is fitted with a battery of nozzles of a type which produce a very finely divided spray, and are so arranged that the air is completely scrubbed on each spiral revolution up the vessel. Dust particles are hit by the minute water droplets and carried by them to the side of the vessel where the dust laden water runs down the side, is collected at the bottom, drawn off, filtered, and returned to the pump suction for reuse. The amount of water circulated is between 5 and 10 gallons per thousand cubic feet of air scrubbed, using a pressure drop of between 50 and 100 psi through the nozzles. The pressure loss of the air stream through the scrubber is usually held to 5 in. of water.

Figure 3 — The reversing heat exchangers are for a 175-ton oxygen plant. Photograph was taken when these were ready for insulation.



The compressed air is cooled to 80 F before entering the reversing exchangers. This is usually accomplished in conventional shell and tube exchangers, with circulating cooling water allowing a 20 F rise in the circulating water temperature. During part of the summer months it may be necessary, in locations where the sustained cooling water temperature exceeds 75 F to use additional cooling with circulated chilled water. One economical method of producing this chilled water for part of the year is by steam jet refrigeration. For such type units, the steam can be either at high or low pressure and the balance between steam and water consumption is quite flexible. An average consumption using 8 lb steam, would be about 2½ gpm water and 12 lb per hour of steam, per ton per day of oxygen capacity.

Reversing valves—The 80 F compressed air is distributed to the exchanger system through a set of reversing valves which control, not only the entrance of the air to the system, but also the return of the oxygen product and the nitrogen streams. The number and size of these valves vary from ten (4 and 6 in. sizes) for a 10-ton plant, to as many as twenty-two (as large as 30 in.) for a large capacity plant. Valve operation is either hydraulic or pneumatic, and is controlled by an electric timer actuating small solonoid valves on instrument air circuits. No attention by the operator is required.

Valves 6 in. and smaller, are single seated, quick opening type diaphragm operated valves, with low pressure drop characteristics. Their bodies are bronze, with seat, disc, and trim of stainless steel. Valves above 8 in. are non-lubricated, full port plug valves, so sized that for example, a 20-in. valve can be fully opened or closed against 100 psig in 2 seconds. This type of valve, has bodies and plugs of cast iron with monel facings. Each individual valve is hand-ground to obtain a tight closure.

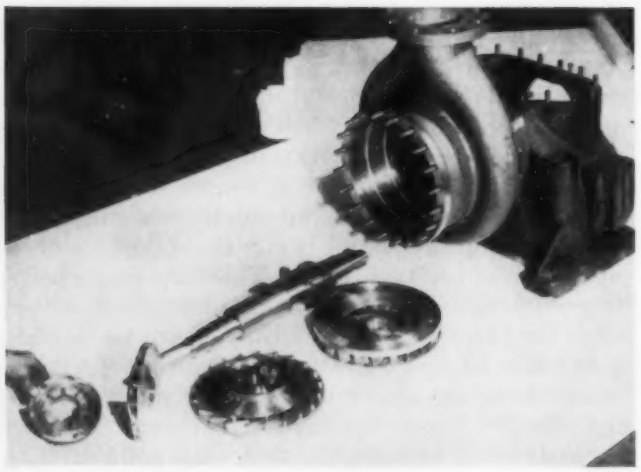
At the cold end of the reversing exchanger, special check valves are provided to switch the flow upon reversal from one annular section to the other. The prime impulse for this switch or reversal comes from the reversing valves at the warm end of the exchanger, of which one set is opened to near atmospheric pressure allowing oxygen and nitrogen to flow out from the low pressure tower through the low pressure check valve and proper annular passage in the reversing exchanger, while the other set of reversing valves allows high pressure air to flow in through the other annuli passage in the reversing exchanger and through the high pressure check valve into the high pressure tower. These valves operate at a temperature as low as -280 F and materials used, as well as the type of design for low pressure drop, require special consideration. The moving part is a flat disc of type 304 stainless steel with guides on each side closing either by spring or by its own weight against a flat annular stainless steel plate seat with a clear opening in the center equal the area of the pipe line in which it is installed. This plate seat is bolted between flanges in the pipe line, so that the pipe itself takes the place of the valve body. Since the annular plate seat is larger than the normal pipe line size flange, increasers are installed in the pipe line just before and just after the flanges holding the plate seat. This type of construction has resulted in a very tight valve, in

fact, tests indicate that the leakage, with 100 psig differential is less than $\frac{1}{10}$ of 1 per cent per hour of the flowing quantity.

Reversing exchangers—It is probable that the reversing exchangers are the most important single item in the oxygen plant. Upon the proper functioning, long life, and continuous service of this equipment, depends the economical operation of the plant. There has been developed a unit which combines a tremendous amount of surface in a small volume with ruggedness and comparatively low cost.

The reversing exchangers consist of a large number of individual tubular elements, each having two annular passages, all manifolded together in parallel. In this exchanger, the 80 F compressed air is cooled to about -270 F by the cold oxygen and nitrogen return streams from the fractionating section. For most efficient heat transfer, both annular passages in these elements are attached together with especially designed fins. The design of the exchanger and its fins is based not only on the heat transfer, but also on its ability to progressively retain the ice and CO_2 deposits laid down by the air as it is cooled, and to progressively give up these same deposits to the cold oxygen and nitrogen streams being warmed up when the flow of the exchanger is reversed. So each of the annular passages functions first, for air cooling and for ice and CO_2 deposit, and then for oxygen and nitrogen heating and for ice and CO_2 pick-up. Each element consists of 3 concentric tubes; an outer tube, a middle tube, and a core tube, all of 3S aluminum with aluminum fins almost completely filling the annular spaces and attached to both the outer and inner surface of the middle tube. For heat balance, as well as for manufacturing ease, the individual elements are designed and fabricated as two separate sections and then joined together by welding to form individual elements which are set vertically and are assembled into shipping units. In the bottom or warm section, the core tube is pinched off at one end so that no flow can pass through it, making the warm section a 2-passage section, while on the top or cold section, the core tube is a special extruded tube with longitudinal fins on the inside and is used for the passage of the cold recycle stream, making the cold section a 3-passage section. The recycle stream enters at the top of the core tube and leaves at the welded joint between the warm and cold section, through an outlet formed by banding and extending the core tube out through the middle of the outer tube walls.

Figure 4 — The air expander is shown disassembled in this illustration.



The fin construction and arrangement is the same in both the warm and cold sections. The fins are fabricated from thin aluminum sheet in annular shape, with a small shoulder about $\frac{1}{16}$ in. deep on the inner and outer edge. The area between these shoulders is pierced with radial cuts and the metal between these cuts twisted 90 degrees so as to form radial openings and radial metal wings. The fins are pressed on to the outside and inside of the middle tube and spaced about 130 to the foot with their radial position staggered so that the wings of one fin are centered over the holes of the next fin. The finned length of the section varies from 8 to 12 ft, depending on the design volume and pressure drop. The fins and tube are brazed together so as to produce a homogeneous structure and destruction tests have shown that the joint between the fin and the tube is stronger than the fin and that this strength persists at the low operating temperatures. The resultant individual element has an extremely high heat transfer efficiency. Hot and cold sections are individually tested for pressure drop and are assembled in single elements of two sections each, so that the resultant pressure drop through each individual element is the same. Elements are hydrostatically tested for strength and tightness.

A number of elements are arranged vertically in groups of from 10 to 30, spaced 6 to 12 in. apart and manifolded together with pipe headers connecting the inner and outer annuli separately at the top and bottom, forming an assembly commonly called a harp, because of its shape. The core tube in the cold section, used for the reheat, is also connected with headers. Each harp has two headers at the bottom (an outer annulus header and an inner annulus header), one header at the middle (the reheat header), and 3 headers at the top (an outer annulus header, an inner annulus header, and a reheat header). Each harp with its attached headers is a shop fabricated unit, and its maximum size is determined by shipping clearances. At the job, the harps are stacked beside each other and connected by cross headers so that flow is in parallel through each individual element. The headers and cross headers are all carefully investigated for pressure drop so as to assure uniform distribution to all elements.

Fractionating equipment—The fractionating equipment consists of a high pressure tower usually designed for 100 psig maximum, and a low pressure tower designed for 15 psig maximum, together with various exchangers, condensers, filters, etc. In the smaller capacity plants, the fractionating equipment is fabricated as a combined vessel, with the low pressure tower placed above the high pressure tower and with a vertical condenser-reboiler between them. Several of the other heat exchanger duties in these smaller plants are also handled by coils installed in advantageous locations in this combined tower. In the large plants, towers and exchangers are separate vessels. All of these vessels are subject to temperatures between -270 and -320 F, and

the most economical material is usually 3S grade aluminum.

Type 304 stainless steel and copper is also satisfactory; but ordinarily more expensive. Shells and heads of 3S aluminum are designed according to the ASME code for unfired pressure vessels using a unit stress of 3000 psi for loads occurring in the temperature range of 150 to 250 F and 3500 psi for loads in the range of +150 F to -320 F. Joints are fusion welded and an efficiency of 85 per cent is used. On material 1 in. thick and over, all welds are spot checked by X-ray. All welding is done by the inert gas arc process, using 2S aluminum for the filler metal and argon for the inert gas blanket. Where possible, single V joints are arc welded from the other side. On joints accessible from one side only, back-up strips are used. Tower tray construction is of conventional bubble cap design of 3S aluminum, with sectional type 3S tray plates. Tray design provides for minimum pressure drop. Access to the towers is usually only possible at the top and bottom of each tower by sawing off an 18-in. 3S aluminum weld cap welded to 18-in. nozzles on the tower. Since need for access to a tower, after erection, is extremely rare, this unconventional provision was chosen to eliminate any possible leaking flanged joints. It is quite simple to weld one of these caps back to the tower again.

In the usual type construction, when vessel and piping are both of aluminum, all piping connections on the vessel are made of pipe beveled for welding so that the pipe and vessel are welded together during erection, and present a continuous leakproof system.

Heat exchangers—The temperature gradient in the exchangers of the fractionating system are such that they can be constructed with fixed tube sheets, and here again a completely welded job is used to attach heads to the shell and tube sheet. Tubes and tube sheets are of 3S aluminum with tubes rolled into the tube sheet and tested for tightness before the heads are welded on. Only on filters is flanged and bolted head construction used so that the internal parts may be removed. For the CO_2 filtering, micro porous sheets of stainless steel, formed from flattened tubes are used. The design of all exchangers must provide for minimum pressure drop.

Refrigeration by expansion—The necessary refrigeration, both for initial cooling and also for normal operation is furnished by expanding part of the high pressure chilled air in a highly efficient centrifugal expansion turbine which has been developed comparatively recently, and has contributed greatly to the commercial and industrial success of this oxygen producing cycle. In earlier units, heat was converted into work by means of reciprocating expanders, which were of very low efficiency. The cycle is such that low efficiency of the expander has a very harmful effect on yields. Furthermore, the reciprocating expander required for tonnage units would be very bulky and expensive. The centrifugal unit not only increases the efficiency of the unit, but lowers the plant cost. In addition, the centrifugal unit is far less subject to wear than the reciprocating unit, since there is no physical contact of the parts within the unit, and wear can only occur at the rotating shaft. This particular wear can be minimized by standard and well known use of anti-friction bearings. The centrifugal expander has also the advantage that the location of the cold and warm sections is static. This means that heat leak into the plant can be readily minimized.

The power generated by the expander has been used in some cases to pump cooling water or to provide compressed air at slightly elevated pressures. It is necessary, in such applications, to allow a fair margin of safety in determining the useful work which may be obtained because the expander duty will vary with operating conditions of the plant. For maximum efficiency, the speed of the unit must change with load and the designer must try to keep close to the maximum efficiency of the machine over a wide speed range. The expander may be loaded by any suitable loading machine such as a centrifugal or rotary pump or compressor or an electrical induction generator; the only requirement is that the loading device be sufficiently flexible to meet variations in expander requirements.

Using a two stage high speed radial reaction type of turbine, an efficiency of better than 78 per cent can be obtained. Shaft speeds vary from 25,000 rpm for very small size machines to 8,000 rpm for larger ones. As the temperature of the outlet from the expander is one of the coldest points in the plant, ranging from -304 to -308 F, the rotor shaft and casing are stainless steel. Overhung construction is used for the rotor, necessitating only a single seal and keeping the heat leak between the bearings with +120 F oil and the rotor wheel with -308 F air to a minimum.

Control of the expander and the refrigeration duty is by a throttle valve on the air to the expander inlet with a secondary control on through a valve on the expander outlet. Although for high efficiency, a centrifugal expander is fundamentally a constant volume machine, details of design and construction have been so handled that as much as 40 per cent variation can be taken in weight flows with less than 1 per cent variation in efficiency.

Two expanders are furnished for a plant, each of a size sufficient to furnish the normal refrigeration of the plant. Both expanders are operated for start-up to supply initial cooling. When the liquid oxygen has been produced in the base of the low pressure tower and reboiler to the proper level, one expander is shut off and the load is carried by a single machine.

Piping—In the warm end of the plant, that is up to the reversing valves, carbon steel piping is used with standard valves which are degreased and specially ground to be tight for air or oxygen service. From the reversing valves on, all piping is 3S aluminum with welded joints wherever possible. Forged aluminum weld ells, tees, and reducers are used in the smaller sizes and mitred joints in the larger pipe. Field welding is by the helium shielded arc process. The same weld details are employed as on the aluminum vessels, except back-up strips are used at all field joints. Shut-off and block valves are flanged gate type of B-61 bronze with extension stems and sleeves of stainless steel about 18 in. long so arranged that the packing gland is out of the insulation and the heat leak cut down to a minimum. Control valves for gas lines are butterfly type, with flanged bronze operating discs, and stainless steel extensions, for either the hand wheels or cylinder

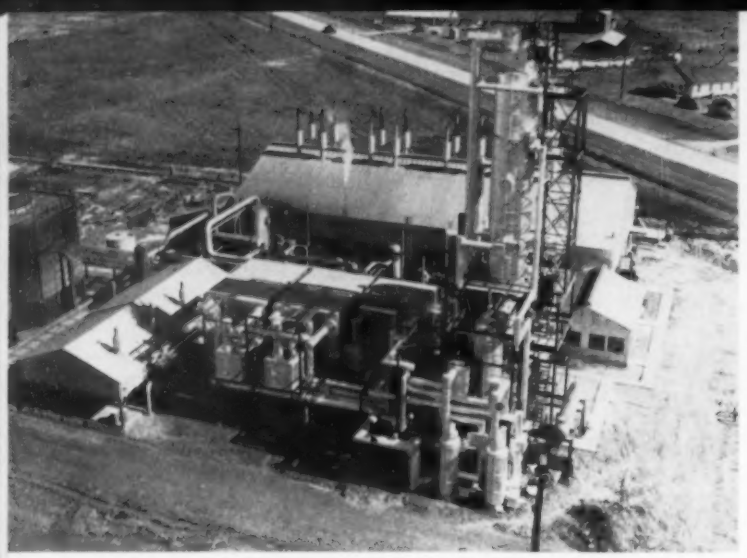


Figure 5 — Aerial view of 175-ton per day oxygen plant. This unit is now in operation.

operators. In liquid lines, the control valves are stainless steel, of conventional V-port design, to which extension stems of stainless steel have been added. Flanged connections between aluminum pipe and stainless steel or bronze valves are made by the use of lap joints on the aluminum pipe, with forged steel lap flanges, type 304 stainless steel bolts and asbestos gaskets. All piping layouts are made as compact as possible, but enough flexibility is provided to handle without overstress, the expansion and contraction due to temperature variations in the piping and equipment. When an excessive length is required for the necessary flexibility, stainless steel expansion joints of the self-equalizing type are used.

Insulation—All piping and equipment in the cold portions of the plant is heavily insulated and the insulation held in place by vapor tight metal jacketing. In a small size plant, cold equipment and piping is so arranged that it will be contained within a single cold box. This cold box consists of a framework on which are bolted aluminum or light gage steel plates. All joints are sealed and the entire box is made vapor tight. The insulation used has been a light, powder-like silica aerogel compound weighing about 5 pounds per cubic foot. This and other silica base compounds now available, have a coefficient of thermal conductivity "X" (expressed in Btu per hour per square foot per inch thickness per degree F) of 0.11 to 0.13 at a mean temperature of -100 F. These silica compounds have not only low conductivity figures, but have also the advantage that they can be placed inside the metal jacketing by blowing; their properties are such that they will completely fill the space and leave practically no voids even around extremely irregular surfaces. Agitation caused by blowing is sufficient to get good packing without tampering or vibration.

The first cooling of the plant with the attendant contraction of the cold equipment will cause some compacting of the insulation material and may require addition of a small amount of material to some of the larger jacketed items of equipment to maintain proper insulation thickness. After the initial compacting, the insulation material will expand and contract inversely with the equipment. For placing the insulation, a small central blower is placed on the ground and the insulation sucked into it from the original shipping containers and distributed by flexible hose to the fill connections provided on the equipment and piping jackets.

Heat stops are used at the supports for equipment as they pass through the insulation jackets, which consist of wood blocks for the small vessels, or stainless steel skirts for the larger towers. Provision is also made for the difference in movement between the cold piping and equipment at -300 F, and the metal jacketing at ambient temperature by providing rubberized fabric joints at proper locations. The fabric is clamped to the metal and sealed to make the joint vapor proof. Similar fabric connections are used with such items as valve handles, anchors, thermo-couples, etc., together with provision made for their free movement.

Controls and instrumentation — Both the normal operation and the start-up of an oxygen plant are unusually simple. To start up a warm plant, air is circulated through the reversing exchanger to both expanders where it is chilled and returned through the other pass of the reversing exchanger cooling of the incoming air. Gradually, the temperatures of the air to the expander inlet and of the system are lowered until the plant reaches the final required temperature. All changes in temperatures and operating conditions of an oxygen plant are very gradual, and automatic control is not necessary except for a few functions in the very large plants. When a plant has been balanced out to the desired flow, as indicated on the flow recorders for air and oxygen product, the air flow is placed on automatic control.

Ratio flow control to split the air stream between the air-oxygen and air-nitrogen reversing exchanger is accomplished with butterfly valves operated by air cylinders. Differential pressure indicators are provided to measure the pressure drop through each annular passage of all reversing exchangers. A strip recorder gives the temperature of the air in, as well as the oxygen product and nitrogen waste out, at the warm end of the reversing exchanger. At the cold end, a recording controller operating on the temperature differential between the air to the fractionator system and the returning oxygen and nitrogen maintains an 8 F difference through butterfly control valves in the cold stream, which can partially by-pass either the oxygen preheater exchanger or the nitrogen equalizing exchanger. In small plants these butterfly valves are hand controlled, and in large plants they are either remote air operated by hand control or completely automatic control. The rich air liquid level in the bottom of the high pressure tower is maintained by a liquid level controller operating on the rich air liquid stream into the low pressure tower. The oxygen liquid level in the bottom of the low pressure tower is maintained by a liquid level controller operating on the volume of air to the expander. Oxygen draw-off is set to the desired amount and regulated by the recording flow controller on the oxygen product line. The outlet temperature on the expander is maintained by a recording temperature controller which varies the expander inlet temperature with a by-pass for the reheat around the reversing exchanger. The nitrogen reflux to the low pressure

tower is controlled by ratio flow controller between the reflux and rich air feed to the low pressure tower.

For all temperature points, except those for which the usual industrial thermometers are suitable, thermocouples of copper constantan are used. All thermocouples in service below 0 F are calibrated to a plus or minus 1 F accuracy for the range of 0 F to -300 F. Couples installed in cold locations are sealed in stainless steel extensions beyond the insulation to reduce heat leak. A dry nitrogen supply taken directly from the high pressure tower is used as a purge and bubbled through the impulse lines to the instruments that measure pressure and liquid level. Operation of the reversing valves is controlled by an electric operated cycle timer equipped with two adjustments, one to set the time before the passages in a reversing exchanger are switched, and the second to set the line the product is allowed to purge to atmosphere before going back on stream again. Either of these adjustments can be made at any time by the operators with an adjustment knob on the outside of the instrument. In addition, the sequence between a set of reversing valves for each reversing exchanger is fixed by a cam and set screw arrangement that can be adjusted.

Experience with equipment employed—Most of the equipment used in oxygen plants has already been proven in other commercial uses. Some of the types of equipment have found an unconventional new application but even in most of these cases, ample data were available from which performance could be predicted. The few items of new material and equipment developed particularly for oxygen plant service had to be carefully studied, tried, and designed for the unusual conditions that had to be met. Now, complete data, based on actual operations and operating data are available. The mechanical features outlined have all been found satisfactory by actual operation, and include many perfecting details as a result of this operating experience.

Application of tonnage oxygen—A partial list of the more important operations where the use of tonnage oxygen or oxygen enriched air may be used follows:

1. Partial oxidation of hydrocarbon gases for the production of:
   a. Synthesis gas for Fischer-Tropsch operations.
   b. Synthesis gas for ammonia, alcohols, acids.
2. Gasification of coal for the production of:
   a. Synthesis gas for ammonia, alcohols, acids.
   b. Synthesis gas for the Fischer-Tropsch process —yielding automotive fuels, diesel fuels, alcohols, high melting point waxes.
   c. High calorific value city gas.
3. Heavy chemical industry for the production of:
   a. Sulphuric acids from sulphur and sulphides.
   b. Acetate rayons.
4. Iron and steel industry in the operation of:
   a. Blast furnaces—especially ferro manganese.
   b. Open hearth furnaces—accelerated meltdown and decarburization.
   c. Ore treatment.
5. Non-ferrous industry in the operation of:
   a. Burning for the recovery of copper, nickel, zinc, lead.
   b. Refining.

In most of the foregoing applications, experiments have been or are being conducted, and in some industries production plants have been constructed and are operating with varying degrees of success. Fortunately, if the economics have been properly applied, process difficulties beyond oxygen manufacturing can be ultimately remedied and improved.

In the case of the steel industry, open hearth furnace application of oxygen for both combustion and decarburization is well-established and necessary refinements well understood. It is confidently expected that the use of oxygen enriched blast for blast furnace operation will be applied on a full scale basis for one large blast furnace before the end of the present year.

In recent times oxygen has been a prominent news item. A good deal has been written, some quite speculatively, about new large tonnage uses for oxygen which have recently emerged from the experimental stage, and we cannot ignore the important role this new tool may play in a national emergency. Consumer-operated plants can be expected to increasingly compete with companies long established for the distribution of oxygen, though the long-term results will probably be evolutionary rather than revolutionary in character.

Commercial oxygen units are now being offered which operate on a sound tried basis, are built of proven materials, equipment, and construction know-how, and have an operating efficiency only dreamed of a few years ago.

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MANUFACTURE OF ELECTRIC FUSION WELDED PIPE

By J. H. MIDDLETON
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Gadsden, Ala.

. . . . the submerged-arc electric welded pipe mill provides an economical method of producing large diameter line pipe . . . .

▲ REPUBLIC Steel Corp. has recently completed a mill to manufacture expanded steel line pipe by the electric fusion submerged-arc weld process. The mill, housed in two buildings, set side by side, and covering approximately 139,000 sq ft, was constructed in 9 months and began operation in 1948. The mill was designed to manufacture pipe with outside diameter of 20 to 30 in., inclusive, with wall thicknesses of ¼ to ½ in., inclusive, in lengths from 27 to 31 ft 6 in. The pipe produced will be used principally for the transportation of natural gas at high pressures.

The various steps in the manufacturing process are basically the same for all diameters and wall thickness. These steps can be grouped into three general divisions: first, the preparation of and formation of the flat plate into cylinders; second, the welding; and third, the sizing of and finishing of the pipe. It is these various steps, which are continuous and at times automatic, that will be described in this paper.

The pipe mill is located adjacent to, and connecting with, a combination 112-in. 3-high sheared and universal plate mill that produces the plates used to manufacture the pipe. The plates from the plate mill are stocked in the building housing the equipment that performs the first division of operations mentioned before.

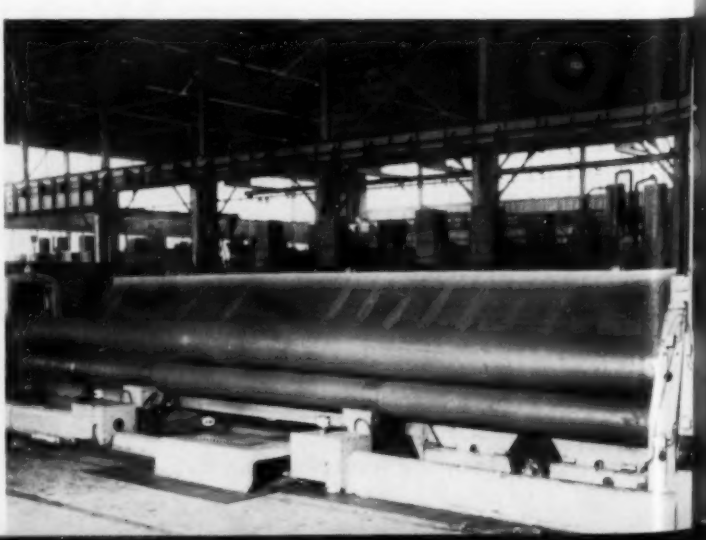
These plates are handled in and out of stock by a 15-ton electric crane with a 113-ft span and on a 575-ft runway. This crane is equipped with twin magnets on one hoist, and a spreader type chain and stirrup sling on the other. Plates are transferred from stock to an area parallel to, and at the side of, the beginning of a roller type conveyor line. This area and the first section of the conveyor is served by a 5-ton, half gantry crane equipped with three electric magnets on a spreader. This arrangement permits the placing of one plate at a time on the conveyor.

The single plate is conveyed lengthwise into a standard plate roller leveler where any out-of-flatness is removed. The plate is delivered onto a conveyor where it is moved forward by traction from motor driven, rubber covered wheels, located above the plate. Vertical movement and pressure is transferred to these wheels by a reversible air cylinder. The wheels contact the top surface of the plate directly above a supporting idler roll. This arrangement is used to move the plates along that part of the preparation line where they remain flat.

In order to form the perfect cylinder needed, both lengthwise edges are planed until they are parallel and a predetermined definite width, depending on the gage and diameter pipe being produced. This edge planing is done on a 36-ft dual planer. The plate is conveyed onto the bed of the planer and is clamped down along both edges by the use of individually acting air cylinders. This prevents any plate movement during the planing operation. The width of the planer bed can be adjusted to the various widths of plates to be planed. The bed of this planer is fixed for a given size and the carriages on each side move. The carriages are powered through triple threaded screws. Each carriage carries a reversible tool head equipped with 5 tools cutting on the forward motion, and 5 tools cutting on the return motion. Each tool can machine approximately $\frac{1}{64}$ in. from the edge of a $\frac{5}{16}$ in. plate. Exact plate widths and parallel edges are very important as will be seen later. Another important requirement is that the plates must have square ends. This is done on two plate shears set across the conveyor line. The ends are sheared while the plate is held tightly against straight guides bearing along one planed edge. The shearing is done one end at a time on separate shears so the plate can be held perfectly flat.

After the plate has been planed and sheared to a

Figure 1 — The edge-formed plate enters the pyramid rolls for final forming of cylinder.



rectangle, it is moved along another section of the conveyor line. Shot blast nozzles are mounted on the sides of this section and are directed at the top and bottom surfaces along the extreme edges of the plate. The spent shot material is returned to a feed hopper by a vacuum line. The suction cups of this line completely enclose the nozzles and the target areas. The purpose of this operation is to remove all oxides and foreign material from both surfaces along the edges. This is done to reduce flux contamination and to promote good welding in a later operation.

The next two operations form the plate into a cylinder. The first machine used forms both longitudinal edges of the plate to make it resemble a wide shallow trough. This forming of the edges is accomplished by passing the conditioned plate through four sets of rolls. These rolls are adjustable for various width plates and for different gages of the same width. The first pair of rolls, aided by guides, keep the plate moving forward squarely into the second set of rolls. The second set of rolls are shaped to turn up the edges approximately one-fourth of the total amount necessary. The next two sets of rolls are shaped to progressively complete the edge forming. The finished turned up edges are formed to a radius of the cylinder to be completed in the next operation.

The edge formed plate is conveyed sideways into a set of pyramid rolls. See Figure 1. The diameter of each of the two bottom rolls is 14 in., whereas the diameter of the top roll depends on the diameter and wall thickness of the pipe to be made. For 24-in. outside diameter pipe of ¼ in. wall thickness, the top roll diameter is 18.66 in. For ⅜-in. wall, a 20-in. diameter roll is used. The 20-in. roll can also be used to make 26-in. outside diameter pipe. For 30-in. outside diameter pipe of $\frac{5}{16}$-in. wall thickness, a 20-in. diameter roll is used. The body length of this roll is 32 ft 6 in.

These rolls are machined straight for the middle 8 ft 6 in. The diameters then taper ½ in. to each end of the body. This increase in section on the top roll compensates for its bending while under load in operation. Both bottom rolls are supported at two points along their length in addition to the end bearings.

The partially formed plate is tilted sideways by lift arms located at the end of the chain conveyor. This allows the turned-up edge of the plate to enter under the top pyramid roll. After the formed edge of the plate is in position, the top pyramid roll is lowered into contact with the inside curved surface along the edge. By rotating all three rolls, the cylinder is formed completely in 2 to 3 passes. The end bearing for the top roll, that is supported on a hinged frame, is lowered and this allows the formed cylinder to be pulled off the top roll. This arrangement delivers a cylinder with a uniform, narrow opening and with square ends.

The cylinders are rolled by gravity to the next operation. Here, they are lined up, one behind the other, lengthwise. The longitudinal edges of each cylinder are matched and temporarily clamped in place with the seam openings at the top. The square ends are tack-welded together on each side of the seam opening. Each tack weld is about 3 in. long. These welds hold the longitudinal edges and also the wall thickness in line for the seam welding which is the next operation.

Figure 2 — After the pipe emerges from the outside seam welder, the operator removes spent flux and examines the finish weld bead.

The formed cylinders in line are then forced through a welding cage which brings the seam opening together so that it can be welded on the outside. Three of these machines are used to maintain a balance in operations. The force needed to push the cylinder through the welding cage is transmitted through three separate power driven, hourglass pinch rolls, located outside and at the top of the cylinder. These rolls are powered through variable speed drives and worm gear reducers. The necessary traction on these rolls is produced by a spherical type roll inside the cylinder and located just beneath the outside roll. This spherical roll is supported by wide, thin arms that are fastened to a frame above and extend down through the narrow seam opening. These supports are held in proper tension by heavy coil springs. At a point 24 in. ahead of the welding cage, a gas burner heats the cylinder wall on both sides of the opening to a temperature of approximately 200 F to burn off any oil and grease present, which, if not removed, would cause inferior welds.

By the time any point on the cylinder reaches the welding cage, the opening is closed and the edges are held tight together by seven sets of five tandem mounted rolls. These seven sets are equally spaced around the circumference of the cylinder.

In addition to these rolls that bear on the body of the pipe, there are two sets each of 14 small rolls supported in heavy water cooled longitudinal bars. These small rolls bear on the top surface of the cylinder on each side of the seam. They prevent any relative movement of the edges to be welded and prevent any disturbance of the weld puddle while still freezing and cooling.

The seam welds are made by the submerged-arc process. The outside seam is welded at a point 24 in. ahead of the exit end of the welding cage. This gives about 24 in. of travel for the deposited metal to cool and grow strong. The welding is done by using twin arcs, one using a-c and the other using d-c. These arcs are about 1¼ in. apart. The d-c arc, known as the leading arc, makes the first contact with the seam. Welding

speeds of approximately 48 in. per min are used, depending on wall thickness being welded.

There is a water cooled, copper backup bar on the inside that slides along the inner surface of the seam just beneath the welding arcs, to prevent them from burning through. This backup bar is supported by a long mandrel which extends back into the cylinder where there is still an opening between the edges of the plate and there it is supported by arms from the frame above.

The d-c arc uses 450 amp with 32-34 v, with the wire as the negative pole. The a-c arc uses 600 amp with 38-40 v. Motor generator sets located within the mill furnish the d-c needed by the welding operation as well as that needed for the cranes and the variable speed drives. The total power requirements for the generator sets and all the other a-c equipment are supplied through four 1000 kva transformers.

A $\frac{5}{32}$-in. welding wire in coils is used throughout the automatic seam welding, both outside and inside. The composition of this wire is approximately 0.18 per cent carbon, 2.00 per cent manganese, and small percentages of phosphorus, sulphur and silicon. The wire is fed continuously to the arcs by air driven motors that are automatically controlled by the voltage drop across the arcs. The flux, developed for this purpose, is fed by gravity onto the seam just ahead of the leading arc. The unused flux is picked up by vacuum on the exit side of the welding cage and is returned to the feed hopper. Part of the flux is fused over the weld and protects and insulates the bead until the flux is removed.

As the welded cylinder is delivered out of the cage (Figure 2), the operator manually removes the spent, fused flux and examines the weld. When the sections have been completed they are separated by cutting through the tack welds with a torch. The sections from the three machines converge into one line again by rolling sideways onto skids set about 8 in. above the floor.

Starting tabs are welded to both ends of the pipe at the points where the inside weld is to be started and stopped. This welding is done manually by using a submerged-arc process.

The outside diameter welded pipe is rolled and conveyed to the next operation, which is the welding of the inside seam. See Figure 3. There are four machines used for welding the inside. The welding heads, flux hoppers and vacuum lines are supported by long stationary cantilever beams. The pipe is positioned with the seam to be welded at the bottom and then locked on a carriage. The pipe on the carriage is moved onto the cantilever beam at a constant rate of 52 in. per min and the weld is made in the same manner as the outside weld. This weld is started on the front tab and stopped on the back weld bead. The inside bead is deposited directly on the inside seam. The position of the bead is controlled by watching the heat penetration from the arcs through the outside bead by means of a mirror held beneath the pipe. Corrections in line-up are made by the use of transverse screws which move the supporting platform on each end of the carriage. Here, again, the unused flux is picked up by vacuum and returned to hoppers on a platform above.

When the inside weld is complete, the carriage is reversed and the pipe is rolled off onto a chain conveyor which delivers the pipe from all four welders to the fused flux removal station.

The fused flux on the inside is loosened by the handling and the pipe is conveyed onto another cantilever beam which supports a vacuum line that picks up the loosened, fused flux and deposits it in sealed bins which are unloaded periodically. When the pipe has traveled its full length, the conveyor is automatically reversed and the pipe is rolled on to another conveyor which delivers the welded pipe to the mill inspection and repair floor. The finished welds inside and outside are examined by company inspectors who mark for repair all sub-standard conditions. General trends away from standards are reported to the welding station responsible for the departure. Corrections are made promptly. At this point, the inside bead is chipped flush with the inside surface on each end of the pipe for a distance of 3 to 4 in. This is done to accommodate lineup clamps for circumferential welding in the field. Small repairs are made by welding manually with a high strength coated electrode. When more extensive repairs on the outside are required, they are made by using a submerged-arc machine.

The pipe then is rolled and conveyed from the conditioning floor to the mechanical end expander. Both ends of each secton of pipe are expanded mechanically for a distance of about 3 in. until the end diameters are up to size. This is done by inserting an expanding head in each end of the pipe. Each head has 12 shoes set around a large hydraulic powered tapered plug. The movement of the tapered plug expands the shoes and the pipe. The length of travel of the plug is regulated to give the final outside diameter needed.

The pipe is next conveyed to either of two sets of skids leading to two hydraulic body expanders. Before entering the expander each end of the pipe is fitted with two-in. rubber gasket rings.

The hydraulic expander (Figure 4), consists of two fixed heads set 32 ft apart but held together with four heavy tie beams. One of the fixed heads is fitted with a movable section supported by four wheels traveling on a track. This movable head is actuated by eight plunger type cylinders equally spaced around the head.

Figure 3 — A general view looking toward inside welders.

The head is pulled back by one piston type cylinder located in the center. This movable head is fitted with a ram whose diameter is the same as the finished pipe diameter. The other fixed head carries the connections for the intake, low, medium and high pressure water, as well as outlet for air. All hydraulic water valves and other expander operations are controlled from a central station and each is operated by a separate oil hydraulic system. In between the fixed head on one end and the movable head on the other, are three sections of split, cylindrical dies which are hinged at the bottom. These split dies are raised and lowered by hydraulic cylinders. In the closed position they form a cylinder and the dies are designed to lock together with a taper grooved beam. This locking beam is moved up and down by means of cylinders.

The pipe, fitted with rubber gaskets as stated, is rolled onto a movable table which positions the pipe lengthwise. The table is also equipped with powered rolls to rotate the pipe so the welded seam will be at the top when the pipe is rolled into the expander dies. The positioned pipe is rolled over the open half of the dies, all three sections are raised, closed and the lock bar lowered. The ram on the movable head is inserted in the end of the dies and locks the pipe against the opposite fixed head. The pipe is filled by using low pressure water. Medium pressure and finally high pressure water is turned into the pipe. The contained air is exhausted during the filling under low pressure. Low pressure water is furnished by centrifugal pumps at 50 psi; medium pressure water by three-stage centrifugal pumps at 500 psi; and high pressure water from two air accumulators and from four 3-cylinder reciprocating pumps operating at 2500 psi maximum pressure. After all the air has been exhausted by completely filling the pipe with water, the pressure is increased until the wall of the pipe yields and is set against the containing dies.

The pressure used for expanding the pipe is approximately 500 psi higher than the test pressure required. These test pressures are usually so set that the pipe will be stressed to 90 per cent of the minimum transverse yield strength specified. These pressures are determined by Barlow's formula and vary with the diameters and wall thicknesses of pipe being produced.

The width of the plates are so planed that when formed into the cylinders and welded, approximately 1.5 per cent expansion is required to bring the outside diameter up to the ordered size. The normal specifications require the finished pipe to have minimum transverse physicals as follows:

Yield strength .....52,000 psi
Tensile strength .....65,000 psi
Elongation in 2 in.....22 per cent

After the pipe has been expanded, the water pressure is lowered to the specified test pressure and the lock bar is raised. The two end die sections are lowered leaving the pipe held between the two heads and the center sections of the split dies. The test pressure is maintained constant for a specified time, and the pipe is struck several blows on both ends with a 2-lb hammer. Then the pressure is decreased to approximately 500 psi and the center dies are lowered. While holding this pressure, the welded seam is inspected for sweats and leaks. The entire pressure cycle on each pipe is recorded on a circular chart which is subject to inspection by the purchaser's representatives.

After the pipe has been expanded and tested, the movable head is pulled back and the pipe is rolled out of the expander onto skid supports where the contained water drains out into receiving pits below. The water is returned by gravity to sumps where any solids are allowed to settle before it is returned to the system.

The pipe rolls by gravity from each expander to the next operation where both ends of each pipe are faced and beveled. At each of the two machining stations, there are two machines set facing each other and the pipe is rolled between them. The machines are equipped with expanding arbors which are inserted into the pipe. These arbors when expanded hold the pipe in line and prevent any out-of-square machining as well as any rotation.

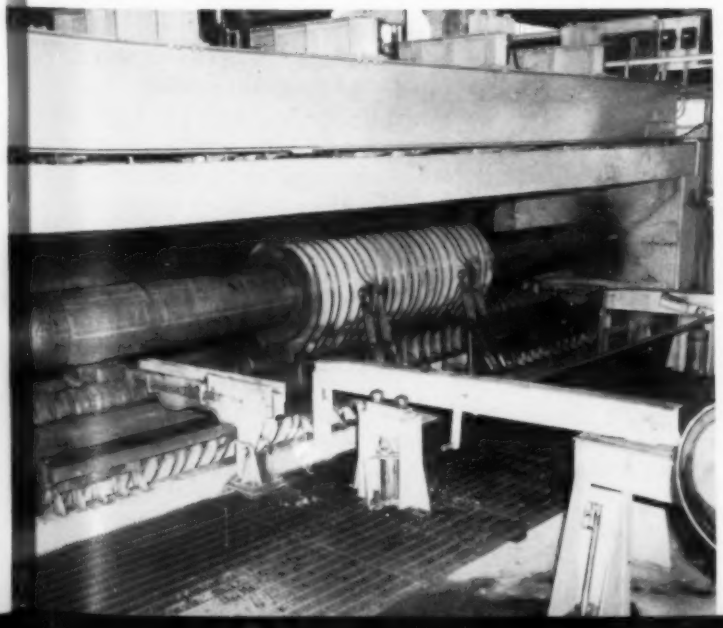
The machining is done simultaneously by three beveling tools and one facing tool on each machine. These tools are mounted on a rotating head whose drive shaft is a cylinder fitted in close tolerance bearings and around the arbors. The feed is controlled by a cylinder fed from an oil gear pump. The bevels are cut at 30 degrees and the flat will average about $\frac{1}{16}$ in.

The machined pipe is rolled and conveyed onto skids where they are given the final company inspection inside and outside. A second inspection station is provided for the purchaser's inspecton and all the pipe are again checked both inside and outside. After the pipe has been accepted, it receives the inspector's stamp, is measured for length and then weighed.

Located in the building where the welding and finishing operations are performed, is a 113-ft span, single hoist, 10-ton overhead electric crane that supplements the chain conveyors and gravity skids in handling the pipe.

After the pipe is weighed it is conveyed to outside storage skids on which the pipe rolls by gravity approximately 500 ft to loading stations adjacent to railroad siding and truck loading area. All pipe are shipped in single lengths of approximately 30 ft.

Figure 4 — One of the hydraulic body expanders is shown with two of the six dies closed and clamping the expanded pipe.



Symposium on Crane Control

. . . . to do the job most efficiently, crane control should be engineered for the actual duty which the crane must perform . . . .

Design of Crane Control

By JOHN D. LEITCH
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▲ THIS paper is concerned only with overhead travelling cranes operated by d-c motors and controlled by magnetic control. In particular, steel mill cranes using mill type motors are discussed.

In the design of controllers for cranes it is necessary to know a great deal about the characteristics of the various components which make up a given controller. These characteristics include the pick-up and drop-out ampere-turns of the various magnetic contactors and relays, the opening and closing time intervals of the various devices, and their continuous and intermittent thermal ratings.

The devices usually associated with d-c magnetic controllers for cranes are contactors, acceleration, plugging and overload relays, resistors, brakes, master switches, and limit switches. The design of a complete controller involves the proper selection of the components and the layout of these components on a control panel completely wired and bussed with all necessary terminals for the convenience of the user.

The availability of a complete line of these control devices is assumed, and most of this paper is concerned with their selection.

MOTOR RATINGS

While the control manufacturer is given the motor sizes by the crane manufacturer, it is customary to review this selection to determine the portion of the motor characteristic curves corresponding to full load. This is particularly useful on the hoist controller, because of the importance of the stability limit of the motor when lowering heavy overhauling loads.

The series motor is used almost universally on d-c cranes because of its desirable speed-torque characteristics. On hoists, it is connected as a shunt motor during lowering and should the load be overhauling, it becomes a generator providing its own excitation in whole or in part and in the case of heavy overhauling loads delivering power back into the line.

The horsepower required on the hoist is given by:

$$\text{hp} = \frac{ws}{33000\ e} \qquad (1)$$

where w = rated hook load in lb
s = hook speed in fpm
e = efficiency of hoist mechanism

This equation neglects the horsepower required during the acceleration of the load and the rotating parts of the hoist mechanism. This additional horsepower is often considered in detail when there is a definite duty cycle such as that encountered on an ore bridge hoist.

In determining the motor sizes for bridge and trolley motions the following equations are useful:

$$\text{Average hp to accelerate rotating parts} = \frac{\Sigma WR^2N^2}{1.61 \times 10^6\ et} \qquad (2)$$

$$\text{Average hp to accelerate structure and load} = \frac{LV^2}{3.18 \times 10^4\ et} \qquad (3)$$

$$\text{Free running hp} = \frac{LVf}{33000} \qquad (4)$$

Where W = weight of revolving part in pounds; R = radius of gyration of revolving part in feet; N = rpm of revolving part at free running speed; t = time in seconds to accelerate from rest to speed N; L = total weight of structure and load in tons; V = speed, in feet per minute, of transverse motion corresponding to N; f = friction in pounds pull per ton of total weight (varies from 15 to 40 pounds per ton).

When rapid acceleration of a large mass is required, as in the case of an ore bridge trolley, the sum of the horsepowers given by equations (2) and (3) is important in determining the motor size; whereas on cranes where the rate of acceleration is less important, equation (4) is of greater significance* (1).

So far the word "horsepower" has been considered as the rate of doing mechanical work. Electric motors are rated in horsepower output at their shafts. A given motor may be rated on a continuous duty basis or on an intermittent basis. For example, an MD408 series motor has a ¼-hr rating of 45 hp, a ½-hr rating of 33 hp, a 1-hr rating of 25 hp and a continuous or 5-hr rating of 13 hp. These figures mean that if the motor is run at its rating for the time intervals specified, it will not exceed its rated temperature rise of 75 C starting from ambient or room temperature. This method of giving motors intermittent ratings is quite satisfactory from the point of view of the motor manufacturer in that the ratings can be determined quite easily. The application of the motor to a given drive is not so easy. It would often be more useful to know the rating of a motor operated at various duty cycles such as ½, ⅓, ¼ time on. Any duty cycle of a few minutes duration can be expressed in terms of the equivalent rms value, and the result compared with the continuous rating of the motor.

A motor operated 25 per cent time on will have an rms value equivalent to its continuous rating if the load on the motor is approximately twice its continuous rating. What is the approximate relationship between the standard intermittent ratings of motors and the short-time duty cycles? This relationship is shown in Table I for an MD 408 motor.

* Numerals refer to Bibliography at end of article.

TABLE I

APPROXIMATE RELATIONSHIP BETWEEN MOTOR RATINGS AND DUTY CYCLE

Rating	Rating in per cent continuous rating	Duty cycle having rms values equivalent to continuous rating
¼-hr, 45 hp	345	8.5 per cent time on
½-hr, 33 hp	245	15.5 per cent time on
1-hr, 25 hp	191	27.0 per cent time on
Continuous, 13 hp	100	100.0 per cent time on

This table is not to be taken too seriously as the duty cycles should be determined by test. The table, however, does indicate the intermittent nature of the duty cycle corresponding to the standard ratings.

It is not customary to express an intermittent duty cycle in terms of the equivalent rms value except in those cases where we have a repetitive duty cycle such as applies to the hoist and trolley motion of an ore bridge. In this case, the calculations are much more complicated and take into consideration the motor current variations throughout the entire duty cycle and reduce them to the equivalent rms current for comparison with the continuous rating of the motor.

The foregoing emphasizes the need for a clear understanding of what is meant by the various motor horsepower ratings. Many years of experience on steel mill cranes favors the ½-hr rating for the motors.

The crane control designer is mostly concerned with the hoist motion. A crane has a definite lifting capacity, and it is desirable to refer to this as full load and express all loads as a percentage of this load. Knowing the full load on the hook, the efficiency of the crane, the gear ratio between the drum and the motor, the rope reduction and the drum diameter, the motor torque corresponding to the full load on the hook can be calculated. The characteristic curves of the motor will then determine the speed and the horsepower developed at the motor shaft. It is customary to make this calculation before designing a hoist controller to learn what points on the motor characteristic curves correspond to full load on the crane hook. The following three examples illustrate the procedure, using the equation:

$$\text{Torque in lb-ft at motor shaft} = \frac{\text{load on hook in lb}}{\text{rope reduction}} \times \frac{\text{drum diam in in.}}{2 \times 12} \times \frac{\text{gear reduction between drum and motor}}{\text{efficiency of crane}}$$

35-Ton Crane — Manufacturer A

$$\text{Torque} = \frac{70000}{4} \times \frac{30}{24} \times \frac{15}{79} \times \frac{13}{58} \times \frac{1}{0.79} = 1180 \text{ lb-ft}$$

Motor MD612, 75-hp, 1-hr, 100-hp ½ hr

Motor characteristic curve at 1180 lb-ft gives 440 rpm, 98 hp

40-Ton Crane — Manufacturer B

$$\text{Torque} = \frac{80000}{4} \times \frac{30}{24} \times \frac{21}{120} \times \frac{19}{86} \times \frac{1}{0.85} = 1140 \text{ lb-ft}$$

Motor MD 612, 75-hp, 1-hr, 100-hp, ½ hr

Motor characteristic curve at 1140 lb-ft gives 450 rpm, 94 hp

10-Ton Crane — Manufacturer C

$$\text{Torque} = \frac{20000}{2} \times \frac{18.75}{24} \times \frac{15}{64} \times \frac{16}{52} \times \frac{1}{0.84} = 671 \text{ lb-ft}$$

Motor MCSA 12, 50-hp, 1-hr, 65-hp, ½ hr

Motor characteristic curve at 671 lb-ft gives 450 rpm, 60 hp

All three of these cranes are operated at or near the ½-hr ratings of the motors when handling full load on the hook. In preparing crane performance curves, all speed-torque calculations must first be made on the motor performance and then transferred to crane performance by allowing for crane efficiency. To eliminate the repeated use of multiplying factors and the resulting confusion, it is desirable that the one to one correspondence between full load on the hook and full load at the motor shaft be maintained.

This can be illustrated by comparing the ½-hr and 1-hr torques and speeds of the MD 612 motor used on the first two of the above three cranes. This comparison is made in Table II.

TABLE II

CHARACTERISTICS OF MD612 MOTOR

At ½-hr rating				At 1-hr rating			
Hp	Full load current	Full load torque	Full load speed	Hp	Full load current	Full load torque	Full load speed
100	375	1250	420	75	275	830	475

The ratio of the ½-hr to 1-hr characteristic varies with the characteristic under consideration. The ratios of the ½-hr to the 1-hr full load characteristics for this motor are torque ratio = 1.48, speed ratio = 0.88, current ratio = 1.37, and hp ratio = 1.33. If the basis of speed and torque calculations had been the 1-hr rating, it would be necessary to say that in hoisting full load on the hook, the motor operated at 133 per cent of its rating and the crane full load hoisting speed corresponds to 88 per cent of motor rated speed. Similarly the torques and currents would be 148 and 137 per cent respectively of their full load values. These ratios also vary widely from motor to motor making a generalization impractical. By choosing the ½-hr rating of the motor as the basis, the correspondence between crane load and motor load is one to one and the need for such factors is eliminated.

SELECTION OF RESISTORS

Resistors are used to limit motor currents during starting and running. In the case of a hoist controller they determine both the armature and field currents during lowering, and control the degree of dynamic braking obtained at the various points on the master switch. Present standards for resistors are expressed partly in terms of the amount of current permitted to flow in the armature with the master on the first point, and partly in terms of duty cycle imposed on them. The standards do not completely define the resistors to be

used on hoist controllers, since this is dictated to some extent by the circuits employed.

In selecting resistors, it is customary to express their ohmic values as multiples of E/I where E is line volts and I is full load amperes. This generalization in the per unit system permits tabulating resistors for any motor size, giving consistency in their selection. For crane controllers, the ½-hr rating of the motor is usually chosen as the basis of all calculations of resistors, and the value of E/I is determined by the corresponding full load current. If the 1-hr rating of the motor is chosen as the basis of resistor calculations, it would be necessary to alter the present standards on resistors in such a way that exactly the same resistors would be chosen.

The selection of resistors for crane controllers is a very important part of the control designer's problem. The subject is sufficiently large to warrant a separate paper, and such a paper by Mr. DuBois follows this one.

BRAKE SELECTION

Magnetic brakes are spring-set and magnetically released. The operating coils may be series or shunt. Hoist brakes, for reasons of safety, have series coils. Trolley and bridge brakes, if used at all, have shunt coils. Magnetic brakes are used only occasionally on bridge and trolley motions mostly as "parking" brakes on the former and "drag" brakes on the latter. Reversing plugging controllers are used on both trolley and bridge motions with foot-operated mechanical or hydraulic brakes on the bridge.

There is no difficulty presented in the selection of the trolley and bridge brakes employing shunt coils, but in the case of the hoist brake, care must be taken in selecting the proper series coil. Like motors, brake coils have intermittent and continuous ratings which may be expressed as ½-hr, 1-hr, and continuous ratings in amperes.

The present standard brake sizes are listed in Table III.

TABLE III

TORQUE RATINGS OF PRESENT STANDARD BRAKES

(in lb—ft)

Series coils		Shunt coils	
½-hr	1-hr	1-hr	Continuous
90	60	90	70
200	135	200	150
525	350	525	400
900	600	900	675
1800	1200	1800	1350
3600	2400	3600	2700

When a magnetic brake has been designed to meet any one of the four torque ratings, the remaining three ratings are approximately established by its thermal properties. Obviously a given brake having fixed outline dimensions will have fixed radiating ability, consequently a coil used at its ½-hr rating will be able to release a greater spring force than the same coil used at its 1-hr rating, hence we refer to the ½-hr and 1-hr torques.

In general, the 1-hr series torque of a given brake design is approximately 2/3 of its ½-hr series torque. Similarly, shunt coils have intermittent ratings, the most commonly used being the 1-hr rating. Shunt brakes are often selected for use at their continuous rating, whereas series brakes are rarely used at their continuous rating. The 1-hr shunt torques are approximately equal to the ½-hr series torques, while the continuous shunt torques are slightly greater than the 1-hr series torques.

The six standard brakes have an adjustable range of torques making each applicable to more than one motor. This demands a series of coils for each brake size, and each coil has its own continuous and intermittent ratings in amperes.

Table IV shows how the above six brake sizes are applied to the 600 series of mill motors.

TABLE IV

APPLICATION OF PRESENT SERIES BRAKES TO 600 SERIES OF MOTORS

Motor frame	Rated motor torque in lb-ft		Rated brake torque in lb-ft	
	½-hr	1-hr	½-hr	1-hr
601	46	29		
602	81	49	90	60
603	116	72		
604	178	121	200	135
606	346	228		
608	514	350	525	360
610	776	525	900	600
612	1250	830		
614	1730	1140	1800	1200
616	2630	1750	3600	2400
618	3980	2560	Takes larger brake than present standard	

Since the brake must be able to hold more than full load on the hook, and since 64 per cent retarding torque at the motor will just balance full load on the hook on a crane which is 80 per cent efficient, it is customary to adjust a hoist brake to full load motor torque or slightly higher. Such an adjustment would hold 150 per cent or more full load on the hook $\left(\frac{1}{0.64} = 155 \text{ per cent}\right)$. This is based on the assumption that full load on the hook corresponds to full load on the motor, and consequently, if the motor full load is at its half hour rating, the brake torque must be equal to this.

Two additional limitations are placed on series brakes. They must be capable of releasing full load torque at 40 per cent full load current and remaining released down to 10 per cent full load current.

It is important therefore that basic full load currents and torques be defined for a crane hoist and its motor. Less confusion results if we maintain a one to one correspondence between full load on the hook and full load on the motor, and if this correspondence exists at the ½-hr rating, such a rating should be recognized.

The foregoing may be illustrated by considering the application of the 1800 lb-ft brake to the 612 and 614

motors. The selection of the series coils is given in Table V.

TABLE V
1800 LB-FT SERIES BRAKE COILS APPLIED TO 612 AND 614 MOTORS

Motor frame	Motor data				Brake coil data		
	Full load torque in lb-ft		Full load current in amp		Turns	Rating in amp	
	½-hr	1-hr	½-hr	1-hr		½-hr	1-hr
612	1250	830	375	275	56	385	290
614	1730	1140	500	360	41	500	375

NOTE: The ½-hr and 1-hr ratings of the brake coils in amperes are equal to or greater than the corresponding full load motor currents.

As the brake shoes wear, the magnetic air-gap increases and the ampere-turns required to release the brake increases for a given torque setting. The brake must be released by 40 per cent full load current up to a definite amount of shoe wear. The amount of permissible shoe wear, before adjustment, is specified by the brake manufacturer. This limit of shoe wear will be assumed to exist in referring to release ampere-turns. The particular brake under consideration has the following release and set ampere-turns at the torque corresponding to the full load torques (½-hr and 1-hr) of the 612 and 614 motors.

TABLE VI
RELEASE AND SET AMPERE-TURNS VERSUS TORQUE

Torque in lb-ft	Release amp-turns	Set amp-turns
830	4300	1350
1140	5300	1500
1250	6000	1700
1730	7600	2000

The higher the torque setting of the brake, the higher the release and set ampere-turns. The information in Tables V and VI is sufficient to determine whether or not the two coils meet the 40 per cent release and 10 per cent set requirements. Multiplying 40 and 10 per cent full load currents by the number of turns in the corresponding brake coil gives the available release and set ampere turns as shown in Table VII.

TABLE VII
AVAILABLE RELEASE AND SET AMPERE-TURNS

Motor frame	40 Per cent full load current x brake coil turns		10 Per cent full load current x brake coil turns	
	½-hr	1-hr	½-hr	1-hr
612	8380	6160	2100	1540
614	8200	5900	2050	1500

From these tables it can be seen that the particular choice of series coils provides sufficient ampere-turns to release the brake at 40 per cent full load current or less and to hold the brake released down to 10 per cent full load current or less. It must be noted, however, that 40 per cent of the ½-hr full load current times the brake coil turns must be compared with the release ampere-turns for the ½-hr rated torque.

It will also be noted from Table V that the ½-hr and 1-hr ampere ratings of the brake coils are in about the same proportions as the ½-hr and 1-hr motor full load currents. The reason for this is the approximate thermal equivalence of the brake and the motor with which it is used. This is not the case for contactors and overload relay coils which have a much lower thermal capacity. Figure 1 illustrates the relative thermal capacity of motors, brakes and contactors by expressing their ½-hr, 1-hr, and other ratings in percent of their continuous ratings.

CONTACTOR SELECTION

The intermittent thermal ratings of contactors are much lower relative to their continuous ratings than the corresponding intermittent ratings of motors and brakes (see Figure 1), consequently care must be exercised in their application. If full load current corresponds to the ½-hr rating of the motor, the currents both during running and acceleration will be correspondingly higher than if the motor were operating at its 1-hr rating. This is recognized in the selection Table VIII for contactors on both crane and mill auxiliary controllers.

TABLE VIII
SELECTION OF CONTACTORS

Contactor continuous rating (in amperes)	Maximum hp (½-hr or 1-hr)	Minimum number of accelerating contactors	
		Crane ½-hr basis	Mill auxiliaries 1-hr basis
100	35	3	2
150	55	3	2
300	110	3	2
600	225	4	3
900	330	4	3
1350	500	4	3

This selection of contactor sizes results in the following application to the 600 series of motors, (see Table IX).

TABLE IX
APPLICATION OF CONTACTORS TO 600 SERIES OF MOTORS

Motor frame	Cranes	Mill auxiliaries
601	100 A	100 A
602	100 A	100 A
603	100 A	100 A
604	100 A	100 A
606	100 A	100 A
608	150 A	100 A
610	300 A	150 A
612	300 A	300 A
614	600 A	300 A
616	600 A	600 A
618	900 A	600 A

The number of acceleration contactors for plugging reversing controllers is exclusive of the plugging contactors and applies only to bridge and trolley drives on

cranes. Crane hoist controllers are considerably more complicated and are not covered by any standard as far as the number of acceleration contactors is concerned.

Since it is not customary to employ contactors rated below 100 A on steel mill cranes and auxiliaries, the 100 A contactor covers a wide range in motor sizes. The reasons for using larger contactors on cranes and one additional accelerator is the greater inertia of the bridge, the trolley and its load as compared to the general run of mill auxiliaries, and the fact that crane motors are worked at higher current levels. Obviously, some mill auxiliary drives have as severe a duty cycle as many cranes, and for this reason, oversize contactors are often called for on blooming mill screwdown controllers at the break-down points of Table IX.

OVERLOAD RELAYS

Magnetic type overload relays are invariably used on cranes. A relay of given design has a large number of coils ranging from a single turn coil of heavy copper strap to many turns of small wire according to horsepower.

Various contactors such as the accelerators and reversers are closed only during a part of a complete duty cycle, whereas overload relay coils are energized during acceleration and running in both directions of motion, consequently they must be chosen such that their continuous rating is approximately equal to the full load current of the motor. Like contactors, their intermittent rating is not much greater than their continuous rating, (see Figure 1) a second reason for selecting them at their continuous rating.

Table X shows the application of a particular magnetic overload relay to the 600 series of motors.

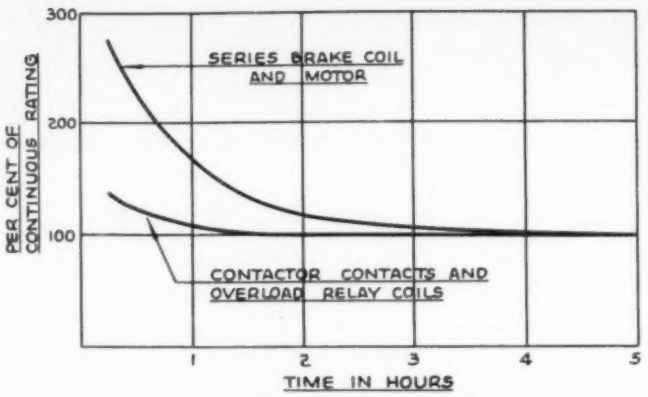


Figure 1 — Curves illustrate that relative thermal capacity of motors, brakes, contactors and overload relays are not necessarily the same.

terms of its frame size. This is imperative if the permissible temperature rise is not to be exceeded.

It is customary to equip d-c crane controllers with two overload relays, one in each line. One of these relays is provided with an inverse time dashpot for overload protection while the other has no dashpot giving instantaneous protection against short circuits or stalled motor. The instantaneous overload relay is usually set to trip instantly at 250 per cent full load current while the inverse time relay is set to trip at 125 per cent.

CRANE PROTECTIVE PANELS

There has been an increase in the use of crane controllers each with its own protection and consequently a decrease in the use of crane protective panels. Crane protective panels have a main line knife switch, two

TABLE X

APPLICATION OF OVERLOAD RELAYS COILS TO THE 600 SERIES OF MOTORS

Motor frame size	Motor hp		Overload coils					
			½-hr rating of motor			1-hr rating of motor		
	½-hr	1-hr	Turns	Hp range	Continuous rating in amp	Turns	Hp range	Continuous rating in amp
601	6½	5	34	5½–7½	32	44	4¼–5	20
602	10	7½	25	8–10	40	34	5½–7½	32
603	13	10	17	11–15	60	25	8–10	40
604	19	15	13	16–20	80	17	11–15	60
606	33	25	7	31–35	140	10	21–25	100
608	45	35	5	41–50	200	7	31–35	140
610	65	50	3	56–75	320	5	41–50	200
612	100	75	3	76–110	440	3	56–75	320
614	135	100	2	111–225	900	3	76–110	440
616	200	150	2	111–225	900	2	111–225	900
618	265	200	1	226–500	2000	2	111–225	900

Referring to Table X, where coils having the same number of turns have two horsepower ranges, the copper cross-section is different. The reason why the range of application is wider for coils having only a few turns is because these coils are wound with heavy uninsulated copper strap, which has very low resistance and greater heat radiating ability, whereas the low horsepower coils have many turns of insulated copper wire.

The overload relay coils must be chosen in terms of the rating at which the motor is worked and not in line contactors, an instantaneous common return overload relay and a single inverse time overload relay for each motion: bridge, hoist, and trolley. In the event of an overload on any one motor or a short circuit, the main line contactors open preventing motion of any part of the crane. Controllers with protection open their individual circuit only, in the event of a fault or overload.

Contactors for crane protective panels are selected on an intermittent basis since all motions are not

continuously in operation. Table XI shows how contactors are rated for crane protective panels.

TABLE XI

CRANE PROTECTIVE PANELS

Contactor continuous rating in amp	Total hp all motions (½-hr ratings)	Greatest hp (½-hr) required by any single motor
100	55	35
150	80	55
300	160	110
600	320	225
900	480	330
1350	725	500

The significance of the last column is to insure that contactor size on the protective panel is at least as large as the largest contactor on any one motion.

ACCELERATION RELAYS

The most commonly used means of closing the acceleration contactors in sequence involves the use of timing relays. Counter emf and current limit relays are rarely used for acceleration on cranes, since it is desirable to force the acceleration up to the point at which the overload relay trips. Acceleration timing relays are available in two forms, those providing definite time and those wherein the time intervals are increased automatically with increase in load. In particular, this latter relay is referred to as a time-current relay responsive to rapid rise of current in the armature circuit. This relay has series coils and wherever series coils are used, they must be chosen in terms of motor full load current, since their timing operation is a function of ampere-turns. Since the series coils are short-circuited by the acceleration contactors, their duty cycle is highly intermittent and the coil selection is not nearly so critical as it is in the case of overload relay coils. They are chosen, however, on the basis of the rating at which the motor is working.

LIMIT SWITCHES

Limit switches are rarely used on bridge and trolley drives, but if such switches are used, they are usually of the track type which opens the control circuit to the line contactors.

Hoist limit switches are an essential part of the hoist controller and may be either the control circuit type or those which interrupt the motor circuit directly. By far the most commonly used hoist limit switch on steel mill cranes is that which directly interrupts the power circuit of the motor and instantly establishes a dynamic braking circuit for rapid stopping of the motor in the hoisting direction. Referring to Figure 3 which shows the power circuit of a typical hoist controller, the limit switch is shown with two normally closed contacts Y1–Y6, and Y5–Y4, and two normally open contacts Y5–Y3 and Y6–Y4.

In the event of tripping the limit switch while hoisting, the counter emf of the motor causes a current to flow from A1, through the now closed contacts Y6-Y4, through the motor field in direction S2-S1, through the limit switch resistor and another pair of limit switch contacts Y3-Y5 to the opposite side of the armature at A2. This circuit causes a reversal of current in the armature, while maintaining the field current in the same direction, a condition necessary for dynamic braking. When the limit switch is tripped, the series brake is deenergized to assist in stopping the motor.

Power limit switches must be selected according to the horsepower of the motor with which they are used, since they carry the motor current through their contacts at all times. The limit switch resistor is chosen such as to limit the dynamic braking current to about full load current corresponding to the ½-hr rating of the motor.

TYPES OF CONTROLLERS

Two types of controllers are used on cranes, plugging reversing controllers on the bridge and trolley motion, and dynamic lowering controllers on the hoist.

Five or six speed points are chosen according to horsepower, six points being used on motors above 110-hp. Figure 2 shows the power circuit of a five-point plugging reversing controller. The controller consists of two pairs of reversing contactors, 1F, 2F, 1R and 2R, three accelerating contactors, 1A, 2A, and 3A, a plugging contactor, P, and a negative line contactor, M. Instantaneous and inverse time overload relays provide protection against fault and overload. The accelerating contactors close in timed sequence under the control of the accelerating relays 1AR, 2AR, and 3AR. The plugging contactor closes on the second point of the controller on starting from rest, but if the motor is plugged, the plugging relay PR prevents closure of P until the motor approaches zero speed. The five points on the master switch (not shown) provide a first point with all accelerators and contactor P open. P closes on the second point, 1A on third, and so on until 3A closes on the last point. If the master switch is moved quickly to the last point, the accelerators close automatically in timed sequence.

The hoist controller is considerably more complicated and varies somewhat among the control manufacturers, although all use the same principle of connecting the

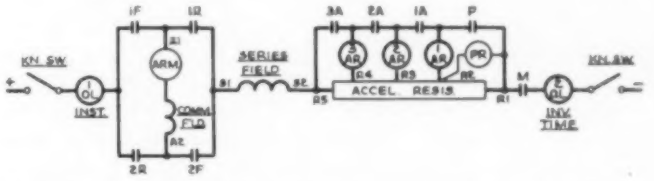
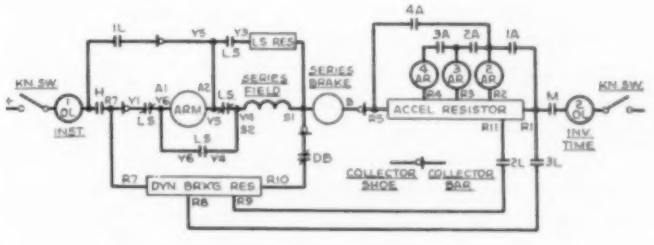


Figure 2 — Diagram is for the power circuit of a 5-point plugging reversing controller.

Figure 3 — One control scheme for a d-c dynamic lowering controller.



motor as a shunt motor in the lowering direction. Figure 3 illustrates one form of dynamic lowering controller.

It is not intended that the following is a complete description of the controller shown in Figure 3. To make the description complete it would be necessary to include the control wiring and go into the safety reasons for the various mechanical and electrical interlocks.

The power circuit alone is shown in Figure 3 and includes a negative line contactor M, hoist and lower contactors H and 1L, a dynamic braking contactor DB, acceleration contactors 1A to 4A and additional lowering contactors 2L and 3L. The overload relays and acceleration relays are the same as for a plugging reversing controller. The power limit switch is shown in the circuit as described earlier. The dynamic braking contactor DB is a spring-closing contactor which closes on power failure. DB is also closed (contacts closed) when the master switch is on either the first point lower or the "off" point.

In the hoisting direction, H and M close on the first point connecting the motor as a series motor, 1A closes on the second point, 2A on the third, 3A on the fourth, and 4A on the fifth. As in the case of plugging reversing controllers 2A, 3A and 4A close in timed sequence under the control of the acceleration relays in the event the master is moved quickly to the last point. The armature current on the first point of the controller is well in excess of that necessary to release the series brake.

In the lowering direction 1L, M, 2A, 3A and 4A close on the first point and DB remains closed. This connects resistor R7–R10 in series with the armature and the field in parallel with both. The initial current is limited only by resistor R1–R2 and with both the armature current and field current passing through the series brake, it releases rapidly. Db opens on the 2nd point of the controller, but not until after 2L closes thus assuring the maintenance of the dynamic braking loop during the transfer. This increases the voltage applied to the armature. On the third point 3A and 4A open to increase the resistance in the field circuit and cause the motor to run at a higher speed. On the fourth point, 2A opens to further weaken the field while on the fifth point 2L opens after 3L closes. This further increases the voltage across the armature for still higher speed.

In the event the load is light, i.e. an empty hook, the motor will act as a shunt motor driving the load downward, but if the load is overhauling, the motor becomes a shunt generator, providing its own excitation and in the event of heavy overhauling load, drives power back into the line. This produces a retarding torque to prevent the load from reaching excessive speeds.

STABILITY LIMIT

The fifth point lowering is that in which the voltage applied to the armature is the greatest and the current through the field the least. Under this condition maximum speed is obtained. The question always arises how far the shunt field can be weakened on the fifth point to obtain high speed lowering of the light hook and yet at the same time not encounter a runaway condition in lowering a heavy load on the same controller point.

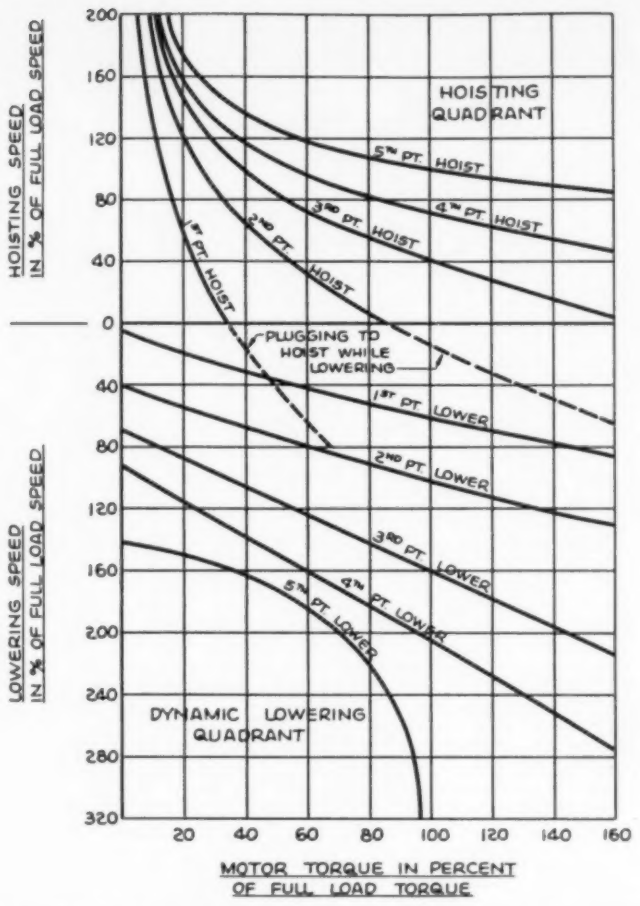


Figure 4 — Typical motor speed-torque for a hoist controller based on ½-hr motor rating.

When lowering a heavy overhauling load under weakened field conditions, the armature current becomes quite large and has a demagnetizing effect on the field, tending to increase the speed still further. If the load is heavy enough, a condition is reached where the retarding torque no longer increases with speed but actually becomes less. This is referred to as the stability limit of a d-c series motor used as a shunt generator.

A great deal of information [2] [3] [4] is available on the characteristics of both the 400 and 600 series of mill motors which enable the control manufacturers to calculate the resistance fillings of hoist controllers such that this stability limit will not be exceeded.

Figure 4 shows a set of typical speed-torque curves for a hoist controller. These curves were calculated on the basis of the ½-hr rating of the motor taking into account the additional inherent resistance of the various connecting leads. The fifth point lowering curve indicates a rapidly increasing speed with a lesser increase in retarding torque. These curves apply to the torques at the motor shaft and do not take into account the retarding torque due to friction

If the full load on the hook corresponds to the ½-hr full load torque of the motor, and the crane is 80 per cent efficient, then in lowering full load, only 64 per cent of full motor torque will be required. When friction is taken into consideration, the crane performance curves corresponding to Figure 4 are those shown in Figure 5. In the case where full load on the hook is somewhat less than the ½-hr rating of the motor, the last point lowering curve will be flatter.

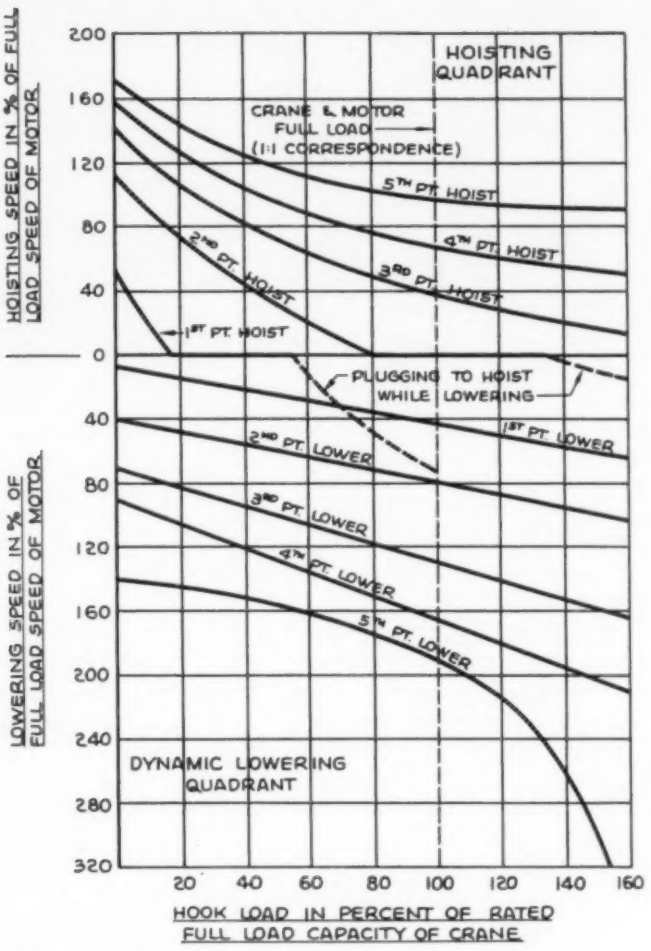


Figure 5 — Crane performance curves with 80 per cent assumed efficiency.

In writing this paper, a great deal of attention has been given to the rating at which the motor is operated. The author understands that the Association of Iron and Steel Engineers is now studying the possibility of having but a single rating for a motor of a given frame size, and that the 1-hr rating is being considered as that rating. (*Editor's Note*: See AISE Standard No. 1, D-c Mill Motor Standards). This would undoubtedly eliminate confusion in the mills since each motor of a given frame size would have the same horsepower rating on its nameplate. However, all calculations of motor speed-torque curves and crane performance curves must be based on some correlation between full load on the hook and full load on the motor. For the sake of simplicity and to eliminate confusion, it is advisable to retain the one to one correspondence and continue to recognize the ½-hr rating so long as the motors are going to be used at this rating on cranes. In any event, regardless of what is on the nameplate of the motor, the controller will conform to the rating at which the motor is operated.

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Crane Resistor Design

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▲ THE problem of designing a resistor for a crane drive consists of two parts. First, the necessary resistance values must be determined and then the required current carrying capacity decided on. Resistor classification numbers have been devised to make a standard by which resistors can be classified. These are useful as a guide and to make sure that all manufacturers are quoting on the same general type of resistor, but they cannot be followed exactly in actual resistor designs. When possible, each resistor should be designed for the actual job it is to perform. The last figure of the classification number determines the total resistance of the resistor, and the first one or two figures designate the amperes carrying capacity which will be needed. Thus a class No. 162 resistor has a total resistance which will allow a current of 50 per cent of full load motor current to flow. The number 16 shows that the resistor will be carrying current 15 seconds out of each 45 seconds. Tests on numerous cranes have indicated that the maximum current peaks for smooth acceleration should be limited to 150 per cent of full load motor current. The contactor timing and resistor stepping should be set so that the resistor steps are cut out when the current drops to about 100 per cent of full load motor current. This gives a root-mean-square current of 127 per cent.

Therefore, the resistor should be designed to have an intermittent carrying capacity of 127 per cent of full load motor current.

Most resistor manufacturers publish tables showing the current values which their resistors will carry for various times. From these tables the proper resistor can be found. The last section of the resistor to be cut out should have a carrying capacity of 127 per cent of full load motor current for the total time the resistor is to be in the circuit. For a class 162 resistor, the last section of the resistor will be in the circuit 15 seconds out of each 45 seconds. The first section of the resistor to be cut out will be in the circuit shorter lengths of time and can have lower carrying capacities.

The total resistance required for a crane drive depends on the maximum speed the motor reaches. The speed at which the motor is operating at the time it is plugged determines the plugging voltage across the resistor. If the motor is operating at twice full load rated speed, the plugging voltage will be approximately three times line voltage. Roller bearing cranes on long

runways sometimes develop plugging voltage as high as 800 volts. If possible, tests should be made to find the maximum speed the motor will be running when plugged and the total resistance figured to limit the plugging current to 150 per cent of full load motor current. On some heavy cranes and bridge trolleys where a fast stop is desired, it is sometimes advisable to use two steps of plugging. The total accelerating resistance should be calculated to limit the current to 150 per cent with line voltage across the resistor. The accelerating resistance is then stepped off so as to give current peaks of 150 per cent when each accelerating contactor closes. This stepping varies some. We have found that steps of 41, 33, 26 per cent on a three-accelerator controller give good results in most cases.

Quite a number of circuits are used on crane hoists. Practically all of the circuits use two sections of resistors. One section is used for acceleration on hoisting and for limiting the field current when lowering. The other section is used in the armature circuit when lowering and in the dynamic circuit in the off position. The carrying capacity should be determined by the worst possible operating condition. Often resistor designers calculate the capacity needed on the assumption that the crane will be operated full speed hoisting and full speed lowering at all times. This may not fit the actual requirements of the crane or the personality of the craneman. If the crane is operated for long periods at reduced speed, sections of the resistor which were expected to be cut out in a few seconds will overheat.

The resistance values of the various sections depend on the type circuit to be used on the load to be handled and on the lowering speed desired, and should be figured out for each individual job.

Electric Control of Twin Bridge Drives With No Torque Shafts

By HARVEY BALL
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▲ THIS paper is written for the purpose of introducing the idea of eliminating line shafts on crane bridge drives by one of two means; either through proper construction of bridge girders and end ties, or synchronization of the motors located at opposite ends of the bridge.

Our first experience in connection with driving crane bridges not using line shafts was with a 350-ton gantry crane (See Figure 1), used on a spillway dam for lifting gates. The power supply is 440-volts, 3-phase, 60-cycles.

The total number of track wheels are 16, each having 33 in. tread diameter. The number of driven wheels is eight. The driven wheels are operated through a gear ratio of 99 to 1 with four 30-hp motors, 900 synchronous speed, 865 rpm. Two track wheels are driven in each truck with an idler gear located between the two gears.

Figure 1 — No torque shaft was used on this 350-ton gantry used on a spillway dam.

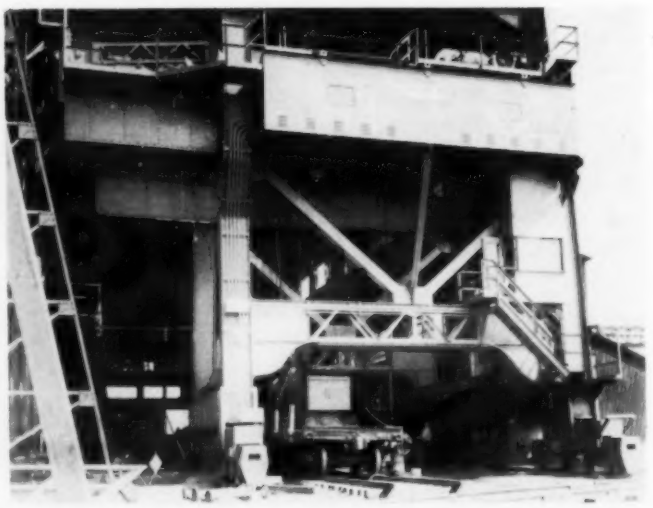
The complete drive which includes the gears, pinions, motor and brake are all mounted directly on the truck unit. This type of drive for this particular crane has four trucks with gear drives, and four motor mountings, and four trucks of the plain type known as idlers. The overall length of one set of trucks plus the equalizer is 17 ft 3 in. This dimension includes the bumper with the springs free. The height of the units is 5 ft 9 in., and the width is 4 ft 0 in. The track wheel bearings are of the anti-friction type.

Our second experience with cranes that were driven not using line shafts was with a 225-ton ladle handling gantry (See Figure 2) on a track center of 34 ft 0 in. This crane was provided with a 15 ft 0 in. cantilever on the furnace end only. The power supply is 230-v, d-c.

The total number of track wheels is 16 having 30 in. tread diameters. The total number of driven wheels are four, operated through a gear ratio of 40 to 1 and using four 45 hp motors shunt wound with a motor speed of 570 rpm. The bridge travel speed is 112 fpm.

The type of gearing used is a worm gear and pinion mounted directly on the track wheel axle, and the

Figure 2 — Gantry type ladle crane is driven through four 45-hp motors. It has no line shaft.



motors are mounted on supports suspended from the bottom end ties. The motors are connected to the worm drives with floating shafts. The track wheel bearings are of the bronze type.

The motors for the bridge motion of this crane are four 45-hp crane rating, shunt wound. The controls for these motors are reversing plugging, quadruplex time current magnetic switch controls. There are two 200-amp, 4-pole single throw knife switches, serving as main line and motor cut-out knife switches, arranged to cut out motors in groups of two, one on each side of bridge. Two resistors each in series with two shunt fields of motors to be in circuit when in "off" position. For further protection of the shunt fields, thermoguards are installed in motor fields to operate an alarm, to signal operator if field coils become overheated which would cause disconnect switch to open.

1—30-amp, double pole control circuit knife switch with NEC fuses.

1—No. 2 type L-4 pole line arc contactor for negative line.

4—No. 2 type L-4 pole line arc contactors for acceleration and plugging.

4—Type S.I. time current accelerating relays.

The above apparatus is assembled on individual slate panels and mounted on angle iron frames complete with back of board wiring, bus bars and control circuit terminal board.

4—Sets of Class 152 type H nickel alloy resistors, consisting of 36 grid sections with grids in series, and only one size grid per section.

1—No. 2 type H, Form G master switch providing five selective speed points in each direction.

1—Limit switch to be connected in bridge motor control circuit.

1—Foot switch by-pass bridge interlock limit switch.

A limit switch was used for the purpose of not allowing the bridge motion control to be operative until the ladle and trolley have been transferred from the cantilever of the crane to a position between the legs of crane, which is obtained by a foot switch. This arrangement is a preventive for a possible unequal loading on the track wheels.

A purchaser wanted to increase their open hearth capacity with the addition of several new furnaces of a larger capacity. They, in turn, asked the crane manufacturer to submit bids on equipment that would be capable of handling this increase. It was decided that a gantry type crane could be designed to take care of this work. A model was made of a gantry crane and submitted to them. It was approved and an order placed after operating this model for a few hours.

The crane is provided with a pouring platform paved with fire brick. At one end of this pouring platform there is an escape compartment lined with asbestos for the stopper operators in case of running stoppers or other difficulties which might arise. Otherwise, the performance of this crane is similar to any other ladle crane.

Our third experience in connection with cranes on which the bridge line shaft was eliminated was a 150-ton shipyard crane (see Figure 3), having a span of 164 ft 0 in. The available current is 230 volts, d-c.

There is a total of 16 track wheels, 27 in. tread diameter. The total number of track wheels driven is eight. These are driven by four, 33-hp motors, series wound, having a motor speed of 635 rpm. Gear ratio is 23 to 1. The travel speed is 198 fpm.

Figure 3 — This 150-ton shipyard crane has no line shaft in spite of the fact the span is 164 ft.

This bridge has a total of eight trucks, four idlers and four driven trucks, each having one motor and gear drive. The wheels in the driven trucks are interlocked by means of an idler gear.

The wheel base of this crane is 40 ft 3 in. center to center extreme wheels. The track wheel bearings are of the bronze type.

Our fourth experience in connection with cranes having no bridge line shaft was a 30-gross ton, 85 ft 0 in.

Figure 4 — Leaving out the line shaft simplifies the design of revolving jib tower traveling cranes.

Figure 5 — The tower crane of Figure 4 is driven by an individual motor at each corner.

radius revolving jib tower traveling crane (Figures 4 and 5), maximum lift at this radius is 110 ft 0 in. above rail and 10 ft 0 in. below rail, making a total of 120 ft 0 in. hook travel.

Maximum height of crane is 169 ft 0 in. Power supply is 230 volts d-c.

The total number of wheels is 16 having 27 in. tread diameter. Total number of track wheels driven is eight. These wheels are driven by four, 33 hp motors, shunt wound, speed 500 rpm. Gear ratio is 27 to 1. The bridge travel speed is 131 fpm.

There are four idler trucks and four driven trucks which have the motor and gear drives mounted on the trucks. The track wheels in the driven truck are interlocked by means of an idler gear. The wheel base of this crane is 40 ft 3 in. center to center extreme wheels, and the track wheel bearings are of the bronze type.

Our fifth experience with cranes on which the bridge line shaft was eliminated was with the double trolley gantry type crane (see Figure 6), 30-ton main trolley, 10-ton auxiliary trolley, span 74 ft 0 in. This crane operates over electric furnaces.

Power supply is 230 volts d-c.

Figure 6 — This double trolley gantry crane is used in an electric furnace plant. Line shaft on such equipment complicates design details.

The total number of track wheels is four having 27 in. tread diameter. Total number of track wheels driven is two. There are two 45-hp motors having a speed of 865 rpm, with a gear ratio of 18 to 1, giving a travel speed of 340 fpm. Each motor is on the same side of the bridge and mounted on the end carriages. The wheel base is 14 ft 0 in. The track wheel bearings are of the anti-friction type.

The control for this drive consists of full magnetic, duplex reversing plugging control panel with necessary resistors, and five speed point master switch to operate the drive motors in parallel. In addition, there are two shunt field rheostats, one for each motor, to permit speed synchronization of the shunt wound drive motors.

Our sixth experience with cranes not having bridge line shaft was with a 20-ton storage yard gantry crane (see Figures 7 and 8), with 5-ton auxiliary hoist, 40 ft 0 in. track span, 26-ft cantilever on one end and 42-ft cantilever on opposite end.

This crane has a total of 16 wheels, 27 in. tread diameter. Total number of track wheels driven is eight. There are four 100-hp motors, series wound, two mo-

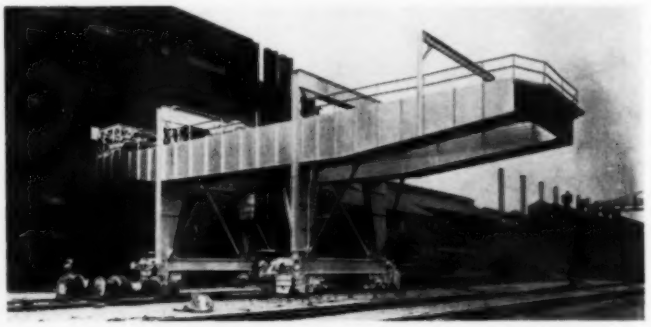


Figure 7 — The stiffness built into this gantry unit keeps it from slewing on the runway.

tors on each side wired in series, having a motor speed of 342 rpm, and gear ratio of 4.56. Travel speed is 500 fpm. Center to center of gantry legs is 28 ft 7 in.

The wheel base of this crane is 31 ft 4 in. center to center of extreme wheels. Track wheel bearings are bronze and are of the enclosed type.

One motor and gear unit is mounted on outside corners of each truck. It is of particular interest that the length of the runway is approximately 2,135 ft. If skewing were a detriment to cranes not having line shafts, it certainly would have been discovered on a runway of this length.

The bridge travels on double tracks, the rails having 24 in. centers. The track wheels are single flange, four wheels in each truck, in other words, two wheels on each axle.

The truck is a self-aligning type, equalizing both parallel with the rails and at right angles to the rails, thus equalizing the bearing box loads, and also the truck loads.

The trucks are of the type that each housing holds 2 wheels, and are connected with an equalizer. On each end of the equalizer there is a tapered supporting member so that the trucks can equalize in a direction parallel with the rails in case one rail is higher than the other.

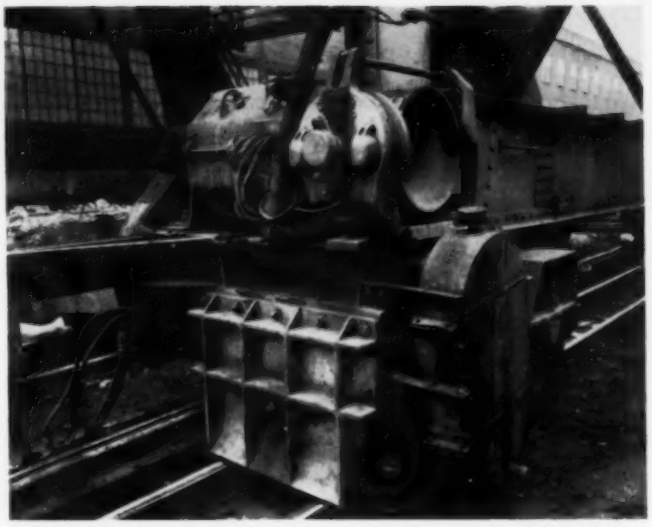


Figure 8 — Box girder sections are extremely effective in giving torsional rigidity to a crane.

After our experience with the above described cranes had proven that electric cranes could be operated very satisfactorily without having line shafts for equalizing the drives, a 300-ton crane (see Figure 9) having a span of 64 ft 6 in. for handling hot metal was designed. This crane has a total of 24 wheels and of this number six are driven, using 45-hp compound wound motors operating at 700 rpm which were mounted on a cradle together with the worm drive and the brake. One end of the cradle was directly connected to the extension on the track wheel axles and the other end of the cradle was supported on an extension from the truck.

The available current is 230 volts d-c and the track wheel bearings are of the anti-friction type. The travel speed is 225 fpm. After this crane was tested for service, the drive as stated above proved to be very satisfactory.

I observed a working model in operation in an electrical company's laboratory, for controlling crane bridge motion on cranes not having line shafts.

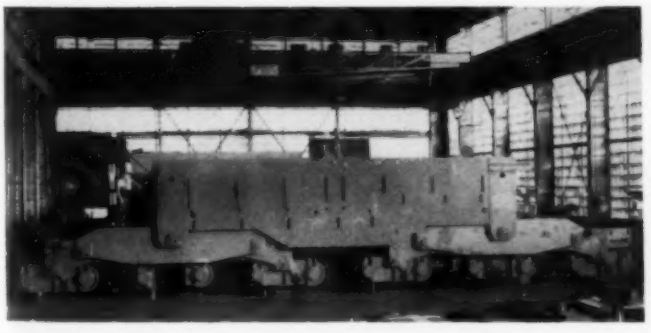
The control is arranged so that no correction is applied when an idler wheel is plus or minus 30 degrees or less out of angular agreement with an idler wheel on the other end of the bridge. Should the skew exceed this limit, the control will operate to slow down the motor driving the leading end of the bridge until the bridge has been returned to a squared condition. If the wheels should get more than plus or minus 90 degrees out of angular agreement, the low voltage protection circuit of the controller will be interrupted, removing power from the motors and setting the brakes. To restore operation a by-pass push button is provided. By depressing this button, only the lagging motor can be operated by the master switch.

Two face plate units are required for this scheme. One unit designated as a "Distributor" is provided with an adjustable flexible coupling for connection to the line shaft. The other unit is designated the "Selector" and it is provided with a flexible coupling for connection to the line shaft.

It is our opinion based on past experience, that this additional electrical equipment while unique, is unnecessary for cranes known as the "Steel Mill Heavy Type Cranes," but is very desirable on cranes of a lighter design, particularly where they do not have a properly designed end tie and girder construction.

In summing up the whole subject, the heart of a crane is in a properly constructed bridge. In other words, instead of driving through a line shaft or squaring shaft that interlocks the drive gears on both ends of the bridge, you have to drive through the girders and end ties.

Figure 9 — No line shafts were used on this 24-wheel, 300-ton, hot metal crane whose end truck is illustrated here.



Possibilities of Standardizing Crane Control

By JOHN A. CORTELLI
Chief Engineer
Clark Controller Co.
Cleveland, Ohio

▲ BEFORE considering what can be done concerning the possible standardization of crane control equipment, it is advisable to review the present standards that have been already established for this equipment by the control manufacturers through their NEMA organization.

NEMA Industrial Control Standards publication 45-97 covers all standards for industrial control. Section IC14-10 to 28 covers control for D-C Cab Operated Cranes and IC14-30 covers control for A-C Cab Operated Cranes. These standards list the basic equipment that is to be supplied on such control. These standards conform to ASA, AIEE Standards.

For example, IC14-28 covers the equipment that is to be supplied on d-c bridge and trolley controllers. A bridge or trolley controller "with protection" will have the following equipment mounted on it.

One —Double-pole isolating knife switch with provision for locking in open position.
One —Double-pole control circuit switch and fuses.
Two—Automatically reset overload relays, one for each side of the line.
One —Undervoltage relay.
One —Negative line contactor.
One —Set of reversing contactors (4 normally open poles), mechanically interlocked.

One—Plugging contactor with means for automatically preventing its closing unless motor is at approximately zero speed.

One—Set of accelerating contactors per IC14-22 with automatic timing means for each contactor.

Still further, the hp rating of the contactors used and the number of accelerators has been standardized and is covered by a table under IC14-22. This table, here called Table I, shows the 8-hr rating of the contactors, the crane rating which is 33 per cent higher than the 8-hr; the corresponding maximum hp rating for each contactor and the number of accelerating contactors for each contactor size.

TABLE I

Standard 8-hr rating, amp	Amp	Hp at 230 v	Minimum number of accelerating contactors
100	133	35	3
150	200	55	3
300	400	110	3
600	800	225	4
900	1200	330	4
1350	1800	500	4

Brake torque ratings are standardized and are covered by IC6-10 to 40. Also Mr. Schlossberg's AISE Committee on brake standardization has started standardization of brake wheel dimensions and of mounting dimensions. The NEMA group working with this committee are at present working on data which should eventually conclude with standardized physical dimensions.

Master switches are covered by IC14 and just recently the direction of throw of master switch handles for different directions has been standardized and clarified with sketches in the standard to show the direction of throw and the relative position of master handle and operator. On these sketches, the direction of throw of the handles, for vertical handles, is away from the operator for FWD or LOWER and toward the operator for REV or HOIST.

Resistors have been standardized as far as classification which covers duty cycle and initial inrushes when starting from rest. This is covered by NEMA Standard IC4-10.

Physical dimensions of resistors have not been standardized because each individual manufacturer has tried to take full advantage of his particular design.

So much for existing standards, what further can be done toward further standardization and particularly on physical overall dimension of crane control equipment? First of all the number of basic pieces of equipment will be the same, however, even though the ratings are the same, some manufacturers will design their individual pieces of apparatus high and narrow while others may feel that a better design can be obtained with short, wide equipment, the end result being that total height and width may have to vary from one manufacturer to another.

The problem is further complicated by auxiliary devices required as accelerating and plugging means, some require series accelerating relays, some shunt relays, others will use pneumatic or timers mechanically operated by contactors, or one may incorporate the timing device right in the contactors. These various timers and auxiliary relays require space and make it rather difficult to standardize overall dimensions.

D-c crane hoist controllers with dynamic lowering present somewhat a more difficult problem in standardization because we not only have the differences in individual component sizes and variations in auxiliary relay equipment required, but also variations in the actual circuits used. Every manufacturer has his own circuit with what he feels are definite advantages in operation, and in many cases the total number of contactors used is different. The situation on crane hoist is somewhat different than that for bridge and trolley controllers because the REV plugging circuits used by all manufacturers on bridge and trolley controllers are very much alike.

The problem of standardized overall physical dimensions becomes more difficult as the number of individual components used increases, whether they be basic contactors or auxiliary devices.

Since most control equipment today is mounted on the bridge structure, it would be desirable to at least standardize the height of panels so that crane builders would have some idea of the clearances required.

I believe that there already exists quite a bit of agreement between manufacturers on panel heights and I do not believe that this would be difficult to accomplish. Many of the manufacturers now use panel heights of 72 to 76-in. high or 60 to 64-in. high.

The enclosure depth can possibly also be standardized for the different sizes of contactors.

In my opinion the depth and height are probably the dimensions that cause the most concern to the crane builder, because there is usually sufficient room lengthwse of the bridge structure to more than accommodate the total length required for the control panels and resistors.

There is one point on resistors which in my opinion could be standardized, and which should be, and that is the size of leads that are run between the control panel and the resistors for intermediate resistor steps. I believe this can be done by adding this data in the NEC Section on cranes. Such a table is in the code for wound rotor secondary resistor leads.

Some of the considerations that should be kept in mind by the crane builder when he is considering controller space requirements along with possible standardization are as follows:

1. Controllers must be serviced, and at times it is necessary to get to the rear of these panels, clear working space should not only be provided on the front, but also in the rear. If it is difficult to get to the rear, then connections made on the rear may not always be tightened properly or made properly to the correct studs. Many operators have experienced hours of time lost when something has gone wrong because a resistor connection had not been connected to the proper stud or had not been tightened because it was difficult and they were inaccessible.
2. Location of resistors, particularly on hoist con-

trollers should be kept close to the control panel in order to avoid excessive lead drop.

3. Brakes require attention and adjustment, and if it is not easy to get to and work on, you may rest assured that it will not receive the proper attention or care in installation.
4. Limit switches must be kept in good safe working order, and here again if it is inconvenient to get to it will not be serviced and may be a hazard instead of a safety device.

In conclusion, a fair amount of standardization has already been done, and some more can be done. However, standardization is usually a slow process and must be done with a conservative and realistic point of view. Initial standardization is always costly to all parties concerned due to new design and tooling costs, and because of the obsolescence it naturally creates. It is only until much later that any appreciable gains are realized.

Reluctance to attempt to standardize is not necessarily an indication of lack of desire to standardize, but quite often the lack of enthusiasm for such a program is due to economic considerations.

DISCUSSION

PRESENTED BY

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JAMES FARRINGTON, Superintendent, Electrical Department, Wheeling Steel Corp., Steubenville, Ohio

JOHN A. CORTELLI, Chief Engineer, Clark Controller Co., Cleveland, Ohio

HARVEY BALL, Assistant Chief Engineer, Morgan Engineering Co., Alliance, Ohio

JOHN A. DRGON, Assistant Superintendent of Maintenance, Carnegie-Illinois Steel Corp., Dravosburg, Pa.

JAMES D. O'ROARK, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

JOHN F. REIS, Engineering Department, Jones & Laughlin Steel Corp., Aliquippa, Pa.

JOHN D. LEITCH, Chief Engineer, The Electric Controller and Manufacturing Co., Cleveland, Ohio

A. W. SCHMITZ, Assistant Division Engineer, Industry Control, General Electric Co., Schenectady, N. Y.

M. A. DuBOIS, Chicago District Engineer, Post-Glover Co., Highland, Ind.

E. R. MUDDIMAN, General Supervisor, Design Engineering, Carnegie-Illinois Steel Corp., Dravosburg, Pa.

V. OSWALD, Electrical Engineer, Electrical Manufacturing and Repair Co., Pittsburgh, Pa.

Marc de Ferranti: Mr. Leitch's comments concerning mill motor ratings are of particular interest to all of us. The facts which Mr. Leitch presented should be taken into consideration in any proposed revision of the method of rating mill motors. It is strongly recommended that a group representing the association of control manufacturers and a group representing AISE give some further joint consideration to this matter and take into account all of the relevant facts, including those presented by Mr. Leitch.

It is true that to suddenly impose on the crane manufacturers the use of one hour ratings (when they have been using only 30 minute ratings for many years) is like asking them to suddenly change from standard American units to metric measuring units in their designs. However, both methods are perfectly correct and can be used with equal facility by those thoroughly understanding both systems. In the application of motors to cranes it is far more important that, regardless of which rating is put on the nameplate of the motor, its application be made, based on a real understanding of the characteristic curves of the machine.

For example, a series wound mill motor, whether it has 30 minute, 15 minute, one hour, or five hour rating on its nameplate is still the same motor and will duplicate the same speed torque characteristic curves.

In applying control to steel mill cranes, it is necessary that a few facts concerning the motor be known:

1. The type of winding—series, shunt or compound.
2. Assuming it to be a mill motor as required by steel mill specifications for cranes, what is its frame size?
3. What construction motor is used—totally enclosed, totally enclosed force ventilated, protected self-ventilated, or protected force ventilated?

In addition, particularly for correct selection of control for the hoist, it is necessary to have complete mechanical data of the hoisting system, as well as some knowledge of the duty cycle to be performed. It is, of course, assumed that from the answers to the questions listed above, it will be possible to secure characteristic curves from the manufacturer of the mill motor.

Even with all of the information discussed above, it is necessary that the designer of the control have a more intimate knowledge of some of the less known characteristics of d-c motors. For example, we have recently been doing some work to determine the stability limits of d-c series wound mill motors, particularly when these are used on crane hoists. The zone of particular interest concerns the use of the series wound motor when it is used with a shunt connection, and particularly under the conditions where it is lowering heavy loads at high speeds. For many years, crane hoist curves have been published, and unfortunately some are still being published, which show straight line characteristics in the lowering quadrant of the diagram. This is misleading. The speed torque characteristics of a crane hoisting system when in the lowering direction have definite breakdown points. If the load on the hook corresponding to this breakdown point is exceeded, the motor will run away in the down direction (instability) and may result in a very serious accident. Some of you have experienced this condition in your mills and may have attributed it to mechanical or motor failure. Actually it could probably be at-

tributed to the manner in which the motor was operated, such that armature reaction effect in the motor caused the runaway. More adequate information regarding these features has been published in the technical press recently and I am sure that all manufacturers of steel mill crane control are now taking it into account in their design of crane hoist circuits.

Referring to Mr. Ball's paper concerning the subject of synchronized drives, or in his case twin bridge drives without squaring shafts, on a-c bridge drives it is common knowledge that a-c wound rotor motors can be applied on each end of the bridge and synchronized by means of using a common secondary resistor for the two motors. The application of such a system should be considered carefully, however, in conjunction with some knowledge of the rigidity of the bridge. In a truly rigid structure, such a system of synchronizing the two ends should not be used, but where the two ends of the structure are rather loosely tied together, the system can advantageously be applied. In the case of twin d-c drives for bridges, I believe that the only factor determining successful application of two independently controlled d-c motors is the rigidity of the structure and this was emphasized by Mr. Ball. The fact that he has had success with twin d-c motor drives, both shunt and series, on bridges without squaring shafts is a good indication of the rigidity of the structures rather than a proof that synchronous ties are unnecessary. With less rigid structures and particularly those in which the two ends are loosely tied together, it would, in my opinion, be necessary to provide some electrical system of keeping the structure square.

You might be interested in the fact that synchronous ties have been used on some of the heaviest traffic bridges in which the only connection between the two ends is an electric cable. Drives for this type of equipment have been of the power selsyn type, although more recently d-c motors have been used for the drives on the two ends. In the latter case, the synchronous operation of the two ends was provided by means of a pilot selsyn and differential selsyn system which causes the fields of the two d-c motors to be adjusted so that the two ends will be kept in step.

With reference to Mr. Cortelli's paper, we favor the type of standardization which he has suggested. It is felt, however, that some additional features should be considered in such moves toward standardization. There is a wide difference of opinion regarding the light hook lowering speeds of cranes. Some types of application need extremely high light hook lowering speeds for most efficient operation. Other cranes give perfectly satisfactory operation with light hook lowering speeds more closely approaching the full load hoisting speed. It would seem possible to set up acceptable standards for these two levels of light hook lowering speeds.

Clark Risler: I would like to add the strength of our opinion to Mr. Leitch's remarks on the retention of half hour rating of d-c motors. We should consider the fact that these motors are used not only by steel mills, readily familiar with one hour rating, but also by other industrial customers who have recognized the value of the mill motor and use it for their purpose, as for instance the Department of Yards and Docks of the Navy, which uses it for their cranes.

James Farrington: What is the ratio between the areas of contactors and the pressure per square inch?

John A. Cortelli: I do not have the figures readily available, Mr. Farrington, it does not work out as a straight line relationship. The ratio between the 600 and the 100-ampere contactor would probably be close to four to one in contact area.

James Farrington: In designing contactors, which do you have more preference for, the area of your contactor tips, or the pressure exerted?

John A. Cortelli: That is also rather difficult to commit myself on, because I think the two of them are pretty closely related. If you do not use so much pressure, you are going to have to go to a larger tip in order to avoid heating, particularly on contactors that are in for a long period of time. I believe we use more pressure than most manufacturers.

John A. Drgon: I would like to ask Mr. Ball a question about his synchronous drives. Do you find any difference between the use of flat wheels and tapered wheels on cranes using this type of drive?

Harvey Ball: That is an easy one to answer, because I do not believe in using wheels having straight treads for cranes. We do not use straight tread wheels unless the customers request them, and that is rather rare. Nor do we use the tapered tread wheel unless the customer specifies their use. We use the wheels having the same radius as the head of the rail.

John A. Drgon: Do you ever use the tapered?

Harvey Ball: Not unless the customer requests the tapered tread. We standardize on a 12 in. radius on rails from 30 lb up to a hundred lb per yard.

James D. O'Roark: Mr. Ball mentioned that on some of those special jobs, the electrical manufacturer recommended shunt wound motors, and that he favored the series wound motor. I would like to know what was the line of thought back of recommending the shunt wound motor?

Also, the examples that he showed us on the screen were more or less special jobs. What would he do in the case of a conventional 50 to 100 ft span, four wheel crane? Would he recommend, if you have a two motor bridge drive, both motors on the same girder, doing away with the squaring shaft?

Harvey Ball: Recently the electrical people recommended that we use a shunt type motor for this application. They were afraid that the series motors might get out of step. We did not have enough of this type machine operating at the time to try it. I requested that they recommend the motors to be in series, but they could not agree with me.

The crane that I am referring to was operating as a yard crane and has two thousand feet of bridge travel. It is driven by series motors. I have ridden this crane and its operation is very satisfactory. The customer is very well pleased with it.

As to the ordinary crane, I will refer you to a crane that is operating over furnaces. It operates in the same manner as an ordinary crane but it has short legs. I would follow the same procedure with the standard crane as I did with this crane.

It operates very smoothly. No trouble whatsoever has been encountered in running up and down the runway. It is a standard crane outside of the short legs.

James D. O'Roark: Mr. Ball, on the series motors you spoke of, are those four motors in parallel, or are they two motors in series on opposite legs?

Harvey Ball: Two motors on each side of the crane are in series, and the pair wired in parallel.

Joseph F. Reis: At this point I would like to ask Mr. Leitch, and Mr. Cortelli what can be done to decrease the size of control panels and devices without decreasing their capacity or impairing their performance—in view of the proposed plans to standardize new designs. These designs could be used for both mill and crane controls. We are familiar with the space required for control panels especially in crane cabs where space is limited.

John D. Leitch: We would certainly like to make our controllers smaller since we fully appreciate the space limitations on crane runways and in crane cabs. We cannot use contactors of lower current ratings without running into problems of excessive heating and wear. Many customers insist on over-size contactors to reduce maintenance costs, which you must admit is a step in the opposite direction. If we were to design smaller contactors for a given rating, we would have to reduce electrical clearances and cut down on pin diameters and bearing areas and this can only be done at the expense of increased maintenance. If we spaced the components closer together on the panel, we would again reduce clearance and have trouble with arcing between them. If we reduce the size of the enclosures, we would receive complaints about the difficulty of bringing in and out the heavy cables. Every time we try to reduce the size of a controller we have immediate pressure for more room and greater accessibility from the maintenance departments.

In steel mills the atmospheric conditions are far from ideal. Conducting dusts and excessive moisture force us to increase creepage distances along insulators and between control components. Many times we have collected samples of steel mill dusts for use in our laboratory during an endurance test of new equipment. Even with all the precautions we take in the laboratory, we frequently find need for still greater clearances to take care of some of the worst conditions encountered in steel mills.

I would also like to refer to the remarks of Mr. de Ferranti. He is quite right in stressing the stability limit of a series motor when used as a shunt generator in lowering heavy loads. We have always realized the importance of this, but we were never able to calculate the true speed-torque curve corresponding to the last point lower with a heavy overhauling load on the hook until we had more information on the characteristics of the motor.

A few years ago Mr. Heumann and Mr. Smith of Mr. de Ferranti's company presented a paper before the AIEE on the stability limits of d-c series motors when used on crane hoists. That paper gave us the so-called K factors for the 400 series of motors, such as the cemf per rpm and the torque per armature ampere for various values of field current, both when the motor is used as a series motor in hoisting and a shunt generator in lowering.

In applying this information, it is important to know what points on the motor charactersitic curves correspond to full load on the hook. Since in most cases these points correspond to the ½-hr rating of the motor, we prefer to use the ½-hr currents, speeds and torques as the base values in discussing crane performance. This we shall continue to do as long as the crane builders select the motors such that full load on the hook corresponds to the ½-hr rating of the motor. If we were to express the full load torques, speeds, and currents on the 1-hr basis, we would lose the one to one correspondence between full load on the motor and full load on the hook. This would only lead to confusion in the calculation of resistor fillings, and in the interpretation of crane performance curves.

I should like to compliment Mr. Ball on his paper on what I might call a "stiff" crane. By employing a stiff structure he greatly simplifies the control problem and at the same time eliminates the need for squaring shafts. The device which Mr. Ball saw in our laboratory is in the development stage and has never been tried. If the crane on which we apply it is sufficiently stiff, it will more than likely not be necessary to use it.

Harvey Ball: Mr. Rice asked a question, and I want to supplement Mr. Leitch on it, because I know what they are up against and I know what we are up against. Particularly on charging machines.

Open hearth operators now want to see all the floor and inside of the furnaces and still locate control on these machines. Where you are going to locate the control I do not know. We have about four charging machines, one in particular for copper charging furnaces, concerning which it is difficult to see if they can design the control boards to suit the available space. Where they are going to locate them is difficult to see.

We have three charging machines for which no apparent space is available to put the control because, as I say, they want to see all of the floor, see in the furnaces, and watch the box revolve. We are using take-up reels to meet the requirements. This arrangement will allow the conductors to be out of the way of the operator's vision, and the control boards will have to be designed to keep below the line of operator's vision. On the hydraulic pump motors, they wanted a special control and they did not want the board to interfere with the operator's vision. The customer wanted the board to be located in a horizontal position. It was quite a job for the engineering department, it had to be engineered a second time.

John A. Cortelli: I would like to add a few comments on Mr. Reis' question, on reducing the size of crane control equipment. Probably we could attempt to reduce the size; however, it is just a question of how much maintenance you want to put up with after you get the controller. If you use undersized contactors, you know what you run into; if you use less accelerators you know you are going to have trouble. You men have all had experience where you attempt to reduce size on general purpose control, or machine tool type control and truck control, and I think many of you have found more space to expand the panels and increase the size of them after you put them into your plants, because clearance is a problem. Undersized equipment is a much more serious problem in the steel mills as the conditions that you run into in the mills are entirely dif-

ferent from those that are on general purpose equipment.

A. W. Schmitz: Mr. DuBois referred to a ladle crane installation where the ohmic value of the starting resistor steps had been changed to obtain uniform current peaks and valleys during motor starting. My question is—was it also found necessary to change the time interval between accelerating steps? I am assuming the control was of the magnetic type.

M. A. DuBois: The timing was adjusted to give the desired starting characteristics for the crane. In this case it was desired to get a fast start for the ladle crane bridge. The timing was adjusted to give the fastest possible start, and then the resistor steps were changed to give uniform current peaks.

E. R. Muddiman: I wish to make a few comments regarding motor rating. There has been considerable discussion about half hour versus one hour rating. The formulae in the Standard Iron and Steel Crane Specifications are theoretical formulae, with practical factors, based on years of practice throughout the steel industry on half hour rating. If a person arbitrarily says, "I want to get a larger size motor, so I will therefore specify mill rating," he might get a larger size motor and end up with an undersized control.

From a practical standpoint, I think it is wise to think of crane motors in terms of half hour rating. If you want a motor slightly oversize, it might be good to specify 10 or 20 per cent oversized motor. If you have a particularly heavy duty cycle, do not try to specify mill ratings arbitrarily, but give the electrical manufacturers the duty cycle and let them figure out the electrical requirements.

V. Oswald: I wish to make this comment on the rating of contactors. It might be good practice for some of us to consider, when we are ordering control, to state just what ampere-hour capacity or NEMA rating is necessary. In that way, if you have several manufacturers bidding on the control, there will be no question about what they are bidding on and you will have no question as to what contactor rating you are getting. Depending on the mill application, a certain motor may need either of two sizes of contactors or control in order that reasonable maintenance will be experienced.

CONTINUOUS ANNEALING OF STRIP STEEL AT DOMINION FOUNDRIES AND STEEL LTD.*

▲ BRIGHT annealing is necessary to relieve the stresses caused by cold rolling and, at the same time, to protect the smooth cold rolled surface. There are two methods of bright annealing in use in the steel industry at present. The most common, the batch anneal or process anneal, is carried out under separate hoods in coil form with furnace cycles from 40 to 100 hours.

The newer form of annealing is carried out in a continuous strip annealing furnace in which a single strand of steel is annealed and cooled in less than two minutes. This form of annealing, although in use for at least 10 years, has just recently received serious consideration from producers of cold rolled steel.

The line consists of four units, the conventional striphandling equipment, a double pay-off, welder, loopers, coiler, the alkaline strip cleaner, the four section electric resistance heating furnace, and eight sections of cooling chutes. It is designed to anneal cold strip up to 34 in. wide and 0.0067 to 0.025 gages at speeds up to 300 fpm for 0.010 gage strip.

A comparison of the economics of the continuous and batch annealing processes will naturally be affected by location, fuel costs, space limitations and type of product. In a location where gaseous fuels are expensive and electricity relatively cheap, where space is at a premium or where low coil inventories must be maintained, continuous annealing offers advantages worthy of investigation.

Some of the factors entering into cost comparisons at Dofasco are shown in the following table using an annealing capacity of 5000 tons per month.

TABLE I

Comparison of Continuous and Batch Annealing Based on a Production of 5000 Tons per Month

	Continuous	Batch
Floor space	8,675 sq ft	12,175 sq ft
Capital investment	$1.4	$1
Fuel consumption	500,000 Btu/ton	1,000,000 Btu/ton
Atmosphere	822 cu ft/ton	1,370 cu ft/ton
Maintenance	Same	Same
Inventory	100 coils ahead 50 coils cooling	100 coils ahead 400 coils cooling
Labor cleaning	—	0.25 man hr/ton
annealing	0.39 man hr/ton	0.32 man hr/ton

The batch anneal figures are based on an average of 2½ furnaces with 6½ bases, using a charge weight of 90 tons (for capacity of 5000 tons a month in foregoing table).

The advantages of continuous annealing on the furnace described are of sufficient importance to warrant a careful study of similar but newer and more efficient furnaces by all producers of steel of tin plate gage.

*Abstracted from paper of the same title presented by W. R. Weir, Dominion Foundries and Steel, Ltd., at Chicago Regional Technical Meeting of AISI, December 1, 1950.

PROGRAM

ANNUAL SPRING CONFERENCE

SPONSORED BY

THE ROLLING MILL COMMITTEE

OF THE

ASSOCIATION OF IRON AND STEEL ENGINEERS

HOTEL STATLER

DETROIT, MICHIGAN

APRIL 30 - MAY 1, 1951

An Invitation . .

The unprecedented, record-shattering expansion now planned for the iron and steel industry is proceeding at a rate deemed impossible only a short time ago. New and ingenious ideas for equipment, better production techniques and improved maintenance practices developed at individual plants are reflected in the industry's greater capacity for production. Many of these developments which have not had industry-wide circulation will be covered at the 1951 Annual Spring Conference of the Association of Iron and Steel Engineers.

You will find it worth your while to attend, and a cordial invitation is extended to you to do so.

JOHN F. BLACK

President, AISE

WALTER L. KEENE

L. C. SOWELL

HOWARD S. AVERY

WARD HOLLAND

Annual Spring Conference Program

MONDAY, APRIL 30, 1951

9:00 a.m. — Registration — Assembly Hall, Ball Room Floor

9:30 a.m. — Rolling Mill Session — Wayne Room

Co-Chairmen:
James N. Imel
Jones & Laughlin Steel Corp.

Paul Carnahan
Great Lakes Steel Corp.

1. "An Introduction to Clad Metals"
   Walter L. Keene, Director of Research
   Superior Steel Corp.
2. "Washington Steel Corp.'s 39-In. Sendzimir Cold Rolling Mill"
   T. S. Fitch, President
   Washington Steel Corp.

9:30 a.m. — Mechanical Session — Michigan Room

Co-Chairmen:
James J. Healy
Armco Steel Corp.

Charles E. S. Eddie
Great Lakes Steel Corp.

1. "Hard Facing Alloys for Steel Mill Use"
   Howard S. Avery, Research Metallurgist
   American Brake Shoe Co.
2. "Modernization of Lubrication for Old Mills"
   Ward Holland, Lubrication Engineer
   Republic Steel Corp.

2:00 p.m. — Rolling Mill Session — Wayne Room

Co-Chairmen:
C. P. Hammond
Rotary Electric Steel Co.

Wade F. Hoffman
Jones & Laughlin Steel Corp.

1. "The Layout and Operation of Bar Mill Finishing and Shipping Departments"
   L. C. Sowell, Superintendent of Blooming and Rolling Mills
   Jones & Laughlin Steel Corp.
2. "Processing Inquiries and Orders for Hot Rolled Sections"
   W. H. Mohler, Superintendent Roll Shops
   United States Steel Co.
3. "Rolling Characteristics of Various Steels"
   Edgar Herold, Superintendent Finishing Mills
   Crucible Steel Co. of America

2:00 p.m. — Electrical Session — Michigan Room

Co-Chairmen:
A. J. F. MacQueen
Algoma Steel Corp.

H. H. Angel
Bethlehem Steel Co.

1. "Handling and Storage of Electrical Parts"
   A. W. McAuly, Superintendent Electrical Department
   Edgewater Steel Co.
2. "Emergency Drive Arrangements for Blooming Mill Auxiliaries"
   F. C. Fennell
   Industry Engineering Department
   Westinghouse Electric Corp.
3. "Developments in D-c Current Drives for Hot Strip Mill Runout Tables and Coilers"
   H. E. Larson
   Steel Mill Division
   Industrial Engineering Divisions
   General Electric Co.

7:00 p.m. — Informal Dinner — Grand Ball Room

Speaker: Richard "Dick" E. Roberts
Manager of Employees Relations Department
Ford Motor Co.

T. S. FITCH

W. H. MOHLER

EDGAR HEROLD

A. W. McAULY

TUESDAY, MAY 1, 1951

9:00 a.m. — Rolling Mill Session — Wayne Room

Co-Chairmen:
D. W. Lloyd
Youngstown Sheet & Tube Co.

A. Krause
Ford Motor Co.

1. "Ingot Track Time — Its Affect on Soaking Pit Heating"
   J. R. Chegwidden, Superintendent of Mills
   Saucon Division
   Bethlehem Steel Co.
2. "Descaling of Carbon Steels in Modern Merchant Mill Practice"
   C. S. Lambert, Superintendent Merchant Mills
   The Youngstown Sheet and Tube Co.

F. C. FENNELL

9:00 a.m. — Combustion Session — Michigan Room

Co-Chairmen:
E. T. W. Bailey
Steel Co. of Canada, Ltd.

A. F. Kritscher
National Tube Co.

1. "The Application of Precast Insulation to Water-Cooled Supports in Underfired Furnaces"
   James E. Hovis, Sales Engineer
   Bloom Engineering Co., Inc.
2. "Metallic Recuperators for Slab Heating Furnaces"
   R. R. Shedd, Design Engineer
   Construction Engineering Bureau
   United States Steel Co.
3. "Some Aspects of Soaking Pit Operation"
   F. H. Graham, Chief Operating Engineer,
   Amsler-Morton Corp.

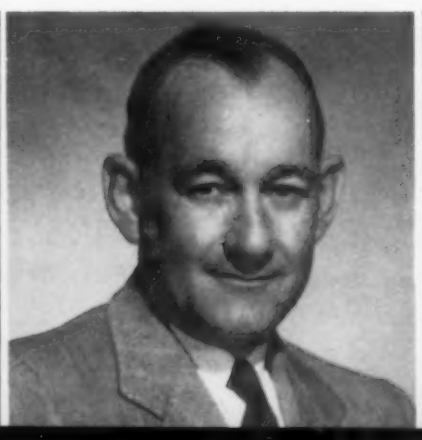
H. E. LARSON

1:00 p.m. — Buses leave Hotel Statler for Inspection Trip to Ford Motor Co. covering steel plant and automobile assembly line.

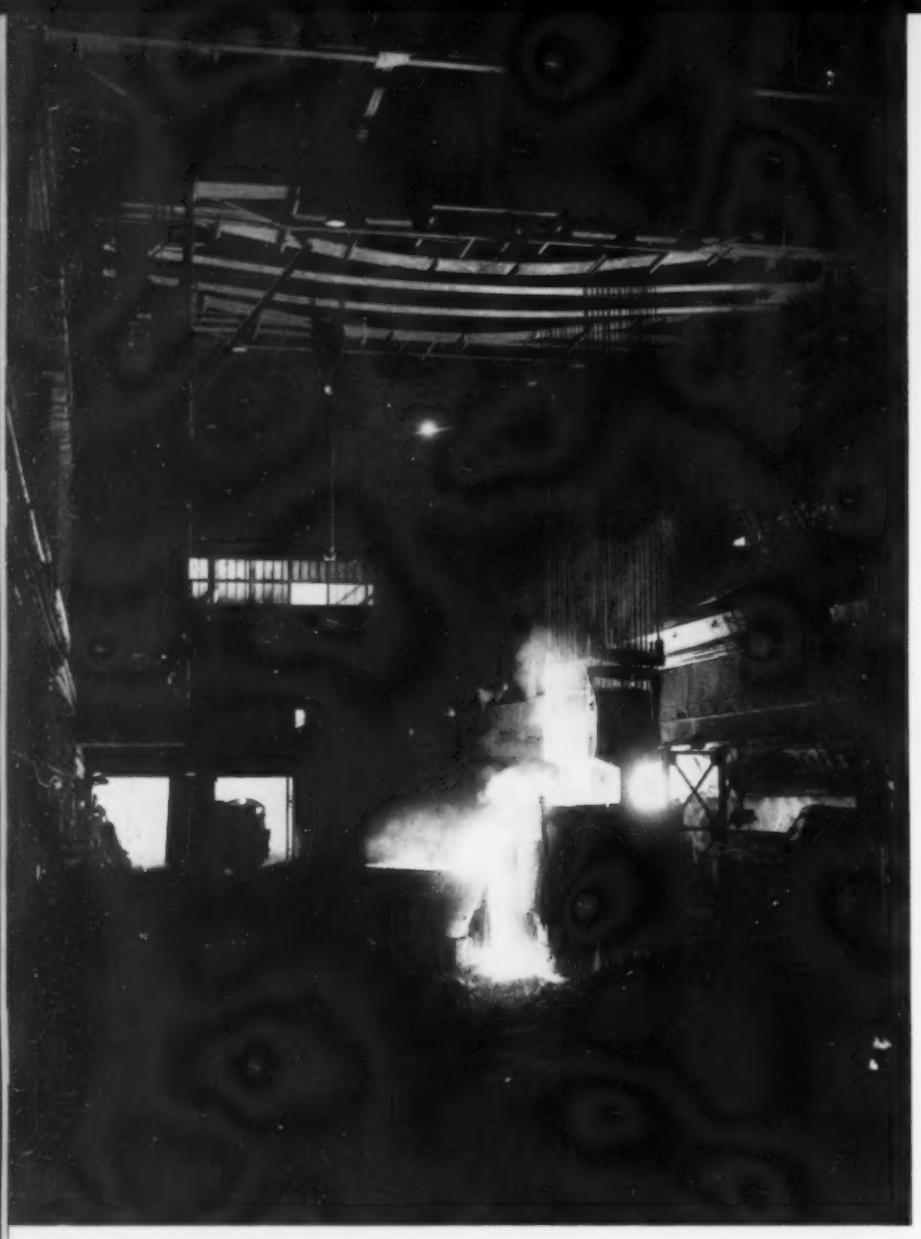
JAMES E. HOVIS

R. R. SHEDD

J. R. CHEGWIDDEN



C. S. LAMBERT



TUESDAY
MAY 1, 1951

AISE
INSPECTION
TRIP

TO

FORD MOTOR COMPANY

RIVER ROUGE PLANT

DEARBORN, MICHIGAN

Buses leave Bagley Street entrance of Hotel Statler at 1:00 p.m.
Trip will cover both the steel plant and the automobile assembly line.
Trip is restricted to citizens of the United States and Canada only.

OPERATING ADVANTAGES AND LIMITATIONS OF OPEN HEARTH CONTROLS

By B. B. BARGMAN
Superintendent Fuel
Carnegie-Illinois Steel Corp.
Munhall, Pa.

. . . . open hearth efficiency and production has increased with the development of control instruments . . . .

▲ INSTRUMENTATION and control of open hearth operations has been expanded gradually during the last two decades and has advanced to a stage at which it may be worthwhile to review and to reconsider the advantages and limitations associated with existing installations. This advancement has accompanied general developments in process control, along with improvements in control equipment.

The concept of control as used here will have reference to the mechanical operation of the open hearth furnace as it improves the quantity and reduces the cost of production. Metallurgical or quality control will be benefited indirectly as the control of any variable will aid in the improvement of the product.

While it has been aptly stated "To Measure is to Control," one of the chief problems in open hearth control work is to obtain a positive measurement of furnace performance. The practice of using relative measurements had to be adopted in some cases, especially with temperature measurement, air volume and furnace pressure.

Much of the development work on open hearth furnace controls has been done on older furnaces. In many cases the capacity of these furnaces had been increased beyond their original size above the floor line, with little or no increase in the downtakes, checker chambers, valves or flues below the floor. Changes of this nature created new operating problems which were accepted in the effort to increase production.

These problems were recognized by the fuel engineers and extensive tests and experiments were made to overcome them. The roof temperature control, for example, was an outgrowth of these endeavors. Its status will be discussed later.

The materials and functions of open hearth furnace operations which can be measured and controlled are fuel, air, steam, furnace pressure, reversal and limiting temperatures of refractories in the roof and checker chambers. Measurements are indicated on suitable instruments which serve as a guide to the furnace operator or first helper, and recorded to show the trends. Management also has these records available for use and future reference.

FUEL

The measurement and control of fuel on open hearth furnaces has always been accepted as being of prime importance and the procedures are well established. Fuel volume control, in one form or another, has always been used. The old time operator devoted much of his time and effort watching his furnace to determine visually its fuel requirements; he then set a manual valve to supply the fuel needed. Today this function is performed automatically by instruments, which, when set to a predetermined amount, will maintain that rate of fuel input to the furnace until the control is reset by the operator.

With fuel volume control now recognized and established, it is possible to set up fixed rates of fuel flow for various stages of the heat or furnace conditions as shown in Table I. These rates are shown on the graph of Figure 1. When the control is set at the fuel rate called for, no deviation or change occurs due to line pressure fluctuations or other variables. The fuel rate

TABLE I

Stage of heat	Fuel, gphr	Steam, lb	Air, cfhr	Furnace pressure, H_2O, in.
Melt down	550	220	600,000	0.12-0.13
Ore boil	450	180	450,000	0.07-0.08
Lime boil	400	140	400,000	0.09-0.10
Refining	480	160	550,000	0.11-0.12

Typical variations of input rates for fuel, air, and furnace pressure.

may be reduced, however, by the effect of the fuel in the furnace, for example, by a roof temperature limit control. (Table II).

The measurement of the fuel also serves as a basis of cost allotment and gives management an important and useful check on operations as expressed in fuel performance. The records are especially useful when tests or experiments are being conducted. Burner efficiency is a subject of almost continuous study, and

TABLE II

OPEN HEARTH FUEL REPORT FOR MONTH OF JUNE 1949

Furnace No.	Net tonnage	Thousand equivalent cu ft of by-product gas @500 Btu cu ft	Equivalent cu ft per net ton	Gal of tar consumed	Gal of fuel oil consumed	Gal per net ton	Btu total per net ton of product (net)
1	14,775	.....	.....	150,146	126,213	18.704	2,803,500
2	10,570	.....	.....	101,647	129,154	21.836	3,246,500
3	14,592	.....	.....	155,196	128,126	19.417	2,911,500
4	15,064	15,142	1,005	133,862	107,220	16.004	2,853,000
5	10,215	.....	.....	145,577	53,298	19.469	2,960,500
6	14,378	.....	.....	142,286	125,829	18.647	2,792,500
7	14,095	.....	.....	130,843	127,502	18.329	2,739,500
8	10,264	.....	.....	97,017	136,067	22.709	3,370,000
9	12,772	.....	.....	149,476	104,229	19.864	2,988,000
10	10,799	.....	.....	99,865	133,483	21.609	3,209,000
11	12,748	.....	.....	164,604	133,842	23.411	3,511,000
Shop average	140,272	15,142	108	1,470,519	1,304,963	19.786	3,011,000

Fuel oil @ 151,100 Btu/gal
Tar @ 160,000 Btu/gal

most modern open hearths today have some type of a test being conducted. Of what value would these tests be without fuel performance records?

Since fuel represents approximately 10 per cent of the ingot cost and large volumes are continuously being used by open hearth furnaces, an installation for fuel measurement and control will easily justify itself costwise.

AIR

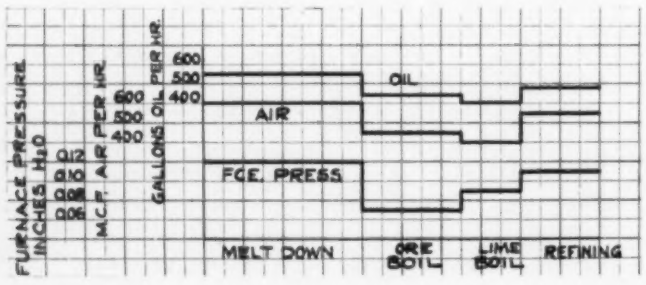
The measurement and control of air, unlike fuel, is not a positive function, since air infiltration prevents complete control of its supply. While suitable equipment is available for air measurement when supplied by forced air fans, the amount of tramp air filtering into the best of furnace systems is so variable that measurements can be only relative. Constant attention, by means of combustion analysis of the outgoing or stack gases, is required.

Combustion control or fuel-air ratio control has been an accepted function on many types of furnaces other than the open hearth. In fact, some cannot work without it. This is true only when a positive measurement of both fuel and air can be obtained. On these furnaces fuel and air is supplied through pipes and ducts, past proper measuring units and volume control valves direct to the burners.

The difficulty in obtaining a positive measurement of total air to the open hearth furnace has, in our opinion, been the greatest obstacle to the successful application and general acceptance of fuel-air ratio in the open hearth. The control of air still remains the major problem of the operator and the fuel man, and must be determined by individual furnace conditions.

Since each furnace has different conditions permitting air infiltration, and since these conditions vary throughout the campaign, combustion analysis affords the best means whereby air requirements can be determined. While total actual air input cannot be measured, provision should be made for measurement and control of that part of the air supplied by the combustion air fan. This will provide the means whereby air volume can be set to compensate for leakage and changing requirements throughout the furnace campaign.

Figure 1 — Typical variations of input rates for fuel, air, and furnace pressure are given in this sketch.



STEAM

The measurement of steam has been well established throughout the industry and therefore atomizing steam presents no particular problem on the open hearth furnace. The value of steam measurement rests with the requirements of the individual shop and can be made either by the pressure or the volume method. Where the piping system is large enough and well balanced, a pressure measurement is sufficient to serve as a control function. With a regulated steam supply from a controlled system or through a pressure reducing station, it is only necessary to set the predetermined pressures by gauge and hand valve to obtain satisfactory control. Volume measurement is necessary only in unbalanced systems or for accounting purposes. Provision for an orifice installation should be made to permit test runs to determine atomizing efficiency and accounting determinants.

FURNACE PRESSURE

The measurement and control of furnace pressure is well established and generally accepted by operators for good furnace performance and fuel economy. Its control serves as a secondary check on combustion air, by reducing air infiltration, and thereby increasing the proportion of the total air which will come through the checkers at a higher temperature. It also adjusts for restrictions or unbalanced conditions in flues, checkers, and valves which may have been built into the original construction, or which may develop throughout the operating campaign.

A typical example of an unbalanced furnace and flue system is shown in Figure 2. This is a 120-ton furnace,

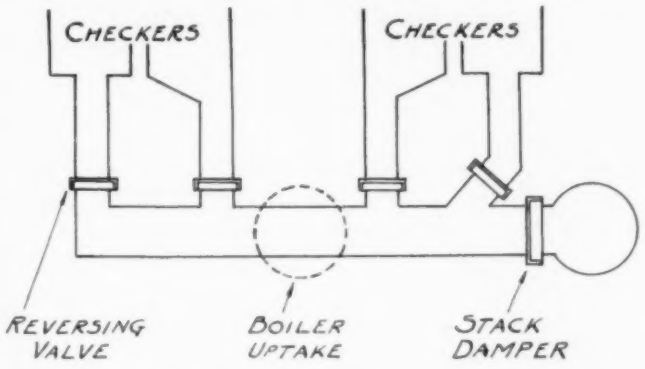
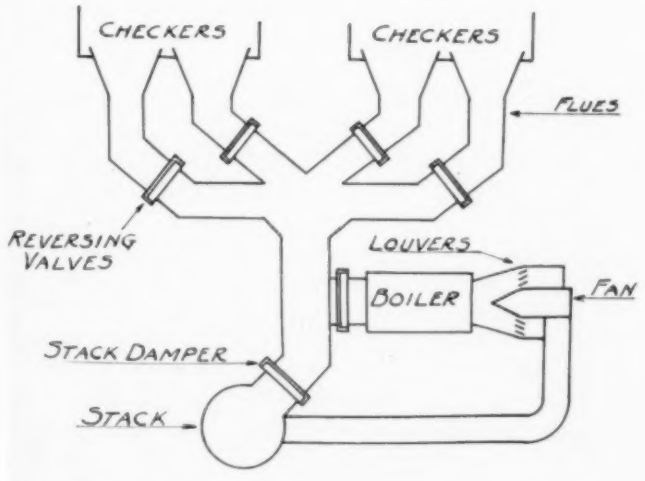


Figure 2 — Furnace and flue system shown is on a 120-ton furnace which is fired with tar and natural gas.

fired with tar and natural gas. It was originally built for natural draft operation, and has since been equipped with a waste heat boiler and induced draft fan. The flue system, valves and stack arrangements are such as to give an unbalanced furnace, and therefore place a limitation on obtaining maximum production without furnace pressure control. Figure 3 illustrates a modern 225-ton furnace balanced flue system. It is fired with either fuel oil or tar and is equipped with a forced air fan, waste heat boiler and induced draft fan.

The full value of furnace pressure control can only be obtained when the proper pressures have been de-

Figure 3 — Balanced flue system for modern 225-ton furnace.



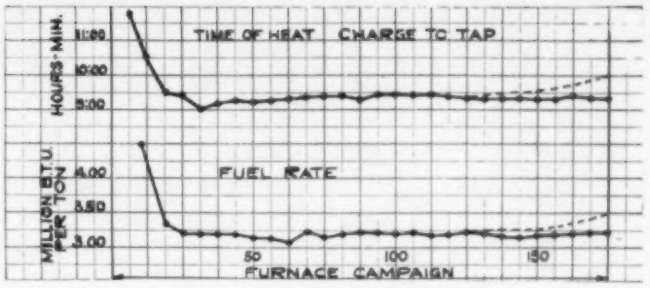


Figure 4 — Curves give typical values for time of heat and fuel rates. Dotted line is for furnace without pressure control and solid line is for furnace with pressure control.

termined so that they may be varied during the heat by the first helper, just as he varies his fuel. These pressures may also be changed as the furnace campaign progresses to correct for changes in furnace resistance.

While furnace pressure control is recognized as an important means of combustion control, it also serves the operator as a production aid. The ability to maintain production rates throughout the campaign is of real value to the operator. Figure 4 illustrates the time of heat and fuel rates through a furnace campaign. It is not unusual for these curves to rise toward the end of a campaign, as shown by the dotted line. The adjustment afforded by good furnace pressure control will help the operator maintain the furnace production rate and keep the fuel rate down.

FURNACE REVERSAL

The fundamental principle of a regenerative furnace requires its reversal. As with fuel, furnace reversal was the second element of operations with which the old timer concerned himself.

Manual reversal may vary widely both in frequency and duration. It can be fully controlled by proper instrumentation and can be set for optimum results within the limits of the speed of operation of the reversing valves and other mechanical equipment on the furnace.

Several methods have been developed to determine when a furnace should be reversed, such as the fixed timer, the variable timer, the temperature difference method, the combination of minimum and maximum time with temperature control intermediate of these two times, and the temperature drop method.

While it is not the intent of this paper to describe the principles of operation of the several controls used on the open hearth furnace, a discussion of the methods listed above for initiating reversal may help in their selection. Reference to a paper by M. J. Bradley on "Open Hearth Furnace Control," 1941 Yearbook AISE and one by J. R. Green and J. P. Volrath on "Reversing Regenerative Furnaces," 1945 Yearbook AISE is also recommended.

The fixed timer may be any unit which will initiate reversal to give uniform time frequency. For example, a cam on a constantly driven shaft in any instrument may operate a contact on a uniform time basis.

The variable timer method may have a single unit or a unit for each end of the furnace; these can be set to

vary throughout the heat, and with two units each end can be set independently to correct unbalanced furnace conditions.

The temperature difference method initiates reversal when a selected temperature difference is reached between the two ends of the furnace.

The minimum and maximum time method, with temperature control intermediate, uses two timers and a temperature controller. The minimum timer determines the shortest time permissible between reversals, and the maximum timer determines the longest time. Intermediate between these two times the furnace is reversed on temperature when the outgoing checkers have reached the same temperature at which the checkers on the opposite end of the furnace were at the preceeding reversal. What this temperature may be is determined when the minimum timer has completed its cycle.

The temperature drop or preheat drop method initiates reversal when the checkers heating the incoming combustion air have dropped by a selected amount.

The method of reversal by temperature difference has proven to be sufficient and suitable for complete control. This system can be set for the optimum regenerative cycle; that is, for the temperature range through which heat transfer to the checkerbrick from the flue gases and from the checkerbrick to the incoming combustion air is sufficient to give the maximum regeneration. Operation at this temperature range results in a time frequency of reversal which reduces as the heat head of the furnace builds up with progress of the heat of steel from charge to tap.

With the acceptance of automatic reversal and the benefits of higher heat transfer, the number of reversals or the number of times the fuel is taken off the furnace has been increased. For our old time first helper, with his dollar watch tied on a shoestring, reversal times were 15 minutes or half hour. Today we think in terms of 6 minutes minimum to 12 minutes maximum. With the increase in the frequency of reversal, duration of the reversal cycle takes on new importance. It is a vital factor which has been overlooked in some installations. The time required for a furnace reversal is usually a constant for each installation, is determined by the type of equipment used, and must be kept at a minimum, as this is a fuel-off period.

The operations of reversal consist of turning the fuel off, purging the burner of liquid fuel, clearing the furnace of spent gases, reversing the air and stack gas valves, and turning the fuel on. These several steps must be performed in the minimum time from fuel-off to fuel-on which should be only long enough to purge the spent gases and bring the combustion air to the oncoming burner.

The individual operations, while requiring the sequence listed, can be overlapped to some extent to reduce the total time. Driving the furnace pressure control damper from its operating position to the wide open position has been suggested as a means of increasing the rate at which the spent gases would be purged from the system and thereby reduce the time required for this part of the cycle. Caution is in order, however, before this suggestion can be accepted. When furnaces are equipped with waste heat boilers, it is imperative that the rate of heat input to the boiler be maintained reasonably constant. If this is not done, a severe disturbance of the water level occurs and results in poor boiler performance. When furnaces are not equipped with boilers and the central position of the damper is disturbed during reversal, recovery to the control position must be fast enough to arrive at the required furnace pressure immediately upon return of fuel to the furnace. Otherwise, the benefits to be derived from faster furnace purging may be nullified by a delay in reaching the maximum heat head with high temperature air from the checker and a minimum of air infiltration.

The importance of keeping the time required for reversing to a minimum can be realized when it is considered that fuel is off the furnace. Although the time reduction may of itself seem small in terms of an individual reversal, when one considers the frequency of reversals, the total time becomes rather startling. As an example, a system was found to require 42 seconds for a reversal. This was rebuilt, using the same reversing damper travel time, so that only 17 seconds were required, giving a reduction of 25 seconds. At 10 minutes between reversals, this totals one hour per day that the fuel was needlessly off the furnace. Any other time reduction is proportional, but when considered on a 24-hour basis, these seconds saved on the reversal operation appear as a real savings.

Bradley in his article states, "It is possible to complete the reversing in approximately from 10 to 12 seconds." In practice there are 225-ton oil fired furnaces reversing in 17 seconds; 120-ton combination tar and natural gas fired furnaces reversing in 14 seconds; and a 75-ton coke oven gas fired furnace reversing in 8 seconds.

TEMPERATURE

The roof temperature limit control was developed in an endeavor to overcome one of the major problems in open hearth operation, that of overheating or burning the roof and thereby severely shortening its life or even losing it entirely. This unit met with a certain degree of acceptance and appeared to have promise of some benefits. However, it met with some very severe operational hazards. Other furnaces making good roof life records without roof temperature control have lessened the potentialities of this type of instrumentation.

The first installations were made with on-off control in which the fuel was reduced by a fixed amount regardless of how much was required. Next came proportioning control, which gives a fuel reduction only as required. The main problem has been to obtain a true measurement of temperature at the critical point of the roof which requires protection. This made it necessary to adopt the method of relative measurement of temperature. Radiation pyrometers were sighted through holes in the back wall or the front wall on the furnace roof. Also special carborundum blocks were installed in the roof near the center with special rigs to hold the radiation units over them. However, holes through the wall became plugged with dolomite, fused brick developed stringers in the hole, roof blocks needed special discs inserted, holes through the roof permitted heat to dam-

age the overhead mounted radiation units, and front and back wall units were constantly subject to damage by crane loads and other operations outside the furnace. These conditions created frequent outages for the roof temperature control units and required the furnace operator to do a good job without roof temperature control.

In one shop which was fully equipped with roof temperature controls, it was found during extended outages of the equipment that the roof life was as good or better than when the controls were operating. In another shop which was only partially equipped, it was found that while controlled furnaces showed improved roof life, other furnaces in the shop improved also and sometimes exceeded those with the controls. Experiences of this type naturally ended in abandonment of roof temperature controls in these shops.

To prevent melting of the checkerbrick, an excess temperature control was developed. It was associated with the reversal control system using checker top brick radiation temperature measurements and functioned by causing furnace reversal when any checker top brick arrived at the danger temperature, regardless of any other reversal requirements. This safety feature was developed for use on older furnaces and may serve well on short furnaces or where overfiring is excessive. With the new modern furnaces with generous downtake fantail and top of checker chamber capacity, the application of this feature may not be necessary.

The status of the thermocouple and the radiation unit is subject to some consideration as a very important part of open hearth controls in which temperature measurement is involved. The methods of making a measurement and their relative cost is well known to those engaged in their use. Both units have been used to obtain a measurement whereby furnace reversal may be initiated.

Experience with the radiation unit has created serious doubt of its justification. This conclusion has been reached because of the difficulty experienced in finding any location for a field of radiation which is constant in its value, and which will hold the same temperature relation in the system as initially accepted. This varies with dust loading on the checkerbrick and with gas or air chamber stratification or even the distribution between chambers.

Due to these difficulties, maintaining furnace balance by the temperature obtained from radiation units has proven a rather hopeless task. On the other hand, the thermocouples placed in outgoing flues, when replaced at the start of each campaign, have proved sufficient to maintain a furnace in balance without any further attention.

Furnaces equipped with combination fuels present a problem when the supply of one or both of these fuels is subject to limitations from their source. The shop may be required to go high or low with one fuel, depending on its availability. In such cases, it may be impossible to set firing rates on the basis of gallons per hour or cubic feet per hour. The total Btu input to the furnace then becomes the operating basis. Meters and controls have been developed and placed in operation with which a gas-to-liquid fuel proportion can be set and maintained with increases or decreases of total fuel input, or, a base flow for one fuel may be set and the other varied as desired.

Bath temperature has long been another problem in the open hearth. The oldtimer used a bar which was inserted through the wicket hole, stirred through the bath for a while and then withdrawn. By visual inspection of the condition of the bar, a temperature relation was determined. A clean cut end indicated the heat was hot, a thin or rat tail end indicated the heat was cold. Thermocouples and radiation units are being used today with results that are very promising. The equipment must be made more reliable mechanically and, as the skill in using them advances, so will their value.

As open hearth operating practices and materials have developed, they have established their worth and will improve with the continued efforts of the operators and engineers. Instruments and controls have progressed with them to a position of real value.

DISCUSSION

PRESENTED BY

E. T. W. BAILEY, Chief Combustion Engineer, Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

A. J. FISHER, Assistant Chief Engineer of Construction, Bethlehem Steel Co., Bethlehem, Pa.

R. A. LAMBERT, Superintendent Steam and Combustion Department, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

HAROLD FLAGG, Combustion Engineer, Armco Steel Corp., Middletown, Ohio

JOHN R. GREEN, Manager, Steel and Ceramic Division, Brown Instrument Co., Pittsburgh, Pa.

BRUCE B. BARGMAN, Superintendent Fuel, Carnegie-Illinois Steel Corp., Munhall, Pa.

E. T. W. Bailey: Mr. Bargman's remarks so closely describe our own experiences that they could have been written of our plant. I like the way he introduces the humanistic elements into his summary. His description of the old time operator fussing about the furnace to ascertain the fuel and other requirements is very realistic. It reminds me of an operator in our plant who for months carefully adjusted the large wheel of the floor stand valve to suit his liking at the furnace wicket. This valve regulated coke oven gas to the furnace prior to the application of fuel oil. The operator confided that just the right pinch of coke oven gas gave him wonderful results in the furnace. When told, he would not believe the valve was in a pipe line that was blanked under the floor.

We have come to the conclusion that the best way combustion engineers can assist the open hearth personnel in improving furnace operation is to:

1. See that the standard instrument tools are kept in good repair.

2. Take frequent analyses of the waste gases entering the downtakes.

For this purpose we have found no better instrument than the heat prover. This instrument shows continuously the varying oxygen and combustible content of the waste gases resulting from adjustments of fuel and air flows. One of the best ways of slowing down a furnace is to have unburnt gases leave the furnace. This can and does happen even though oxygen is present. We test for combustibles as well as oxygen, and increase air flow until the combustibles disappear. The furnaces usually respond favorably to this procedure. A furnace must have extra oxygen to burn off elements in the melt and also to contact fuel molecules in a space which is quickly being filled with inerts towards the discharge end of the combustion chamber.

Collectively, instruments have helped open hearth operation. One can soon sense the most useful ones at the times when they go askew. Just open the bypass on an oil meter and check how long it is before the operator starts to complain.

There is another very promising instrument that Mr. Bargman has not mentioned as such and that is the young operator. Granted, there is no school like the actual working at the furnace; nevertheless, I think many of us miss a bet in not giving the young operators some lessons in elementary combustion and instrumentation as a part of his job instruction.

A. J. Fisher: I would like to divide the open hearth furnace into two main parts with respect to design, first, the items making for furnace efficiency, and second, the items making for flame efficiency. In the building of a new open hearth furnace, we can easily get enough furnace efficiency into the design to make the furnace go as we want it to. We can get enough checkers for air preheat, proper size flues and dampers, and adequate fans to aid instrumentation. In the old furnaces that have been built twenty-five, or more years ago, and then expanded to larger bottoms, we have difficulty in maintaining furnace efficiency. Our company is interested in improving these older type single pass checkered furnaces by getting greater air preheat. There should be some auxiliary means of preheating the air to the single pass checkers. There have been several schemes proposed, but I have not seen any good ones in operation. I think there is a great need for a secondary combustion air preheat for old age open hearth furnaces where there is not sufficient room to install 2-pass checkers. Mr. Bargman's paper on instrumentation dealt principally with maintaining furnace efficiency.

The second part of the open hearth furnace has to do with flame efficiency. The subject deals primarily with using free carbon particles for increasing radiation between the flame and the bath and for developing this effect early in the flame envelope. The ingot production of most open hearth furnaces can be materially increased by the use of selected fuels, atomizing agents, and burners. The study and methods of control of flame efficiency in open hearth furnaces is in its infancy. We should all devote a lot of time to this subject.

Member: The problem of educating the people to the use of controls is one of our most pressing problems and I think our organization, like quite a few other organizations, are eternally seeking some way to do it.

Mr. Bailey commented on the young first helper-operator. I think, through the seniority rules that we have to contend with and the union today, some means must be found to school or educate the people in our organization. They must be instructed as to the proper use of these instruments. We are all sold on the instruments, but the problem of acquainting the first helper with the proper use and control is one that we still have to meet.

R. A. Lambert: With a few exceptions, I agree with Mr. Bargman's paper. There are some items we find advantageous that Mr. Bargman feels otherwise about. One is the atomizing metering. We would not be without steam metering. This is not because of any atomizing problems, but to aid in determining whether or not the "off" and "on" valves at the ends of our furnaces are doing the proper job; that is, whether they are closing tightly and generally functioning properly relative to limit switch operation. We can detect irregularity immediately by observing the chart record of the flow.

Mr. Bargman also mentioned the roof temperature control. We have the roof temperature measuring element located on the roof, and we have found that the roof location is the most advantageous for getting the best results. We do not have too much of a problem with losing the radiation heads. On an average, with fourteen furnaces so equipped we have averaged one radiation head loss in a two-year period. We do not think this is excessive. The only objection we have to the roof location is the safety hazard with tilting furnaces. With stationary furnaces, there is not as much hazard.

Another interesting part of Mr. Bargman's paper, at least very interesting to me, was his exposition of furnace reversal. I think he went into that in very satisfactory detail. He certainly cleared up, in my own mind, some problems and questions which I had.

We had radiation type units installed on our blast furnace stoves and have since removed them and replaced them with thermocouples because we believed that accuracy of temperature measurement was affected by the former. I am inclined to agree with Mr. Bargman that thermocouples in the outlet flues of the regenerators will do a better job than radiation units focussed on some area within the chamber.

Some comments were given about training of furnace personnel and I might mention that, in our plant we have about every eight weeks—classes for the first helpers and second helpers that can leave their furnaces. These classes last for about three-quarters of an hour. Those attending are given instructions for operating the furnace controls and auxiliaries. We illustrate by blackboard sketches, and teach what should be done with the controls to obtain best results. We have found these classes to be mutually advantageous.

There is one question I would like to ask Mr. Bargman. On Figure 3 is illustrated the outlet from the regenerator chamber. This sketch shows a double valve system. I would like to ask if the author believes there is any advantage in having the double outlet rather than a single outlet insofar as the flow distribution of

waste gases through the checkers is concerned. In other words if these double outlets were replaced with single, does he think there would be any difficulty in obtaining good heating of the checkers or would there be too much stratification. This is the first part of the question. The second part is: On the double outlets, having two valves, is there any difficulty in adjusting those valves so as to get the proper flow distribution through the regenerators, and what is the frequency of manipulating and setting them? Also, how is the incoming air provided for?

Harold Flagg: Mr. Bargman said that "to measure is to control." I think he could write in detail on that one text and much of the remainder of the discussion concerning control would be unnecessary. The open hearth is limited by refractories to a top temperature of about 3150 F. If the heat is to be tapped at 2950 F, the temperature potential of the furnace at the finish of the heat is only 200 F. Any influence introduced into the system which may lower this narrow potential is bound to have an adverse effect on furnace performance. The open hearth furnace is inherently a steady load system. If the first helper has good measurement of the fuel and air input to the furnace and can be assured of their regularity, and if he has good measurement of furnace pressure and adequate means for regulation of the draft which establishes that pressure, he has little need for any further refinements in control. Any automatic control installation which must continually be hunting backward and forward to find a control level, is very apt to upset the heating potential of the furnace adversely.

I do not want to cast any reflection on the accomplishments of our friends in the control building business since their contribution has been definitely constructive. I feel that if we can provide better instrumentation and measurement tools to help the first helper find a level of operation which will melt fast and still avoid burning up the furnace, and can train the helpers in the intelligent use of these tools, we will have made real progress toward developing good open hearth practice.

John R. Green: In referring to the fundamental desirability of using temperature differential methods to actuate reversal of an open hearth furnace, the simplest and easiest temperature method of doing that job, the statement was made that the frequency of reversal is increased as the heat progressed. Although this might be true to a very limited extent when operating from thermocouples in exit flues, the sizable benefits are to be secured when reversal is actuated from radiation elements above the chambers. In connection with the use of such elements on checker chambers, later developments and the use of wide angle units to provide entirely satisfactory target areas for consistent measurements have overcome the real problems of those mentioned. It is felt by many that measurements in the hot or working ends of the checkers is the only fully satisfactory method for initiating reversal based upon temperature conditions.

I would like to emphasize what was said about the importance of speeding up the reversal operations by every means that is available. Beyond the actual total of fuel-off time due to reversal, there is a much larger time loss attributable to the fact that furnace temperature has to be regained to a working head after the fuel readmission. Actually, savings in seconds of time in completing the mechanical reversal, can represent savings approaching corresponding minutes in the total time recovery of the working-heat head. This factor can be materially improved by special designs in the fuel flow systems to provide both an earlier and controlled rate of fuel readmission, as well as the earlier admission of combustion air.

A better reference point than time to complete a reversal cycle is the time between fuel shutoff and fuel readmission with the furnace entirely cleared up. This is really what pays off in reducing time heat.

With reference to roof temperature measuring or control systems, the use of roof blocks rather than back or front wall installations, although they are fewer in number throughout the industry to date, has shown a much higher percentage in continuous daily usage.

Bruce B. Bargman: With reference to Mr. Lambert's questions, the double outlets are an advantage in the control of flow distribution of waste gases through the checkers. The opening of the outlet valves can be adjusted to give the draft necessary to overcome uneven distribution of gas flow between checker chambers. Stratification in the present chambers cannot be controlled and it would appear that doubling the chamber on one valve would aggravate the problem.

Proper flow distribution can be obtained within the limits of valve adjustment. The frequency of adjustment must be determined for each furnace by observation of the checkers and/or temperature measurement of gases leaving the checkers.

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The Blooming Mill—

STEEL INDUSTRY'S IRON HORSE

By R. H. WRIGHT
Industry Engineering Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.

. . . . the blooming mill has been such an efficient piece of equipment that its operation and design has changed less than perhaps any other rolling mill . . . .

▲ THROUGHOUT the history of the steel industry there has been a continuous change in the types of finished steel products, in the methods for producing them and in the distribution of tonnages. During all this time blooming mills and slabbing mills have continued to reduce ingots to shapes suitable for further processing. Output has kept up with a rising demand with only a moderate increase in the number of installations, and as a result about 85 per cent of existing installations are over 20 years old. Steam hammers, continuous mills, three-high mills, and two-high reversing mills have been used for making blooms. For all but isolated cases, the two-high reversing mill has now become the standard for doing this work. Reversing blooming mills are available in sizes ranging from 25 to 54 in. Long before the advent of electric drives, two-high reversing mills and reversing universal mills with separate engines for the horizontal and vertical rolls were used for rolling slabs. A magnificent example of the steam-driven universal mill is still in operation in Johnstown, although it is now scheduled to be electrified. These two types of mills are still the standard equipment for rolling slabs.

As the size of the ingots has increased, the mills have become heavier and the lift of the top roll has been been made greater to handle wider ingots and slabs. Especially heavy mills with deeply grooved rolls for rolling beam blanks and car wheel rounds have been built. Mechanical refinements have been made in the design of universal mills. Nevertheless, the basic design of reversing blooming mills and reversing slabbing mills and their auxiliaries has changed very little in the last 50 years. This is not necessarily an indication of lack of progress but shows, rather that the original designs were sound. Operating speeds have not increased but have actually decreased.

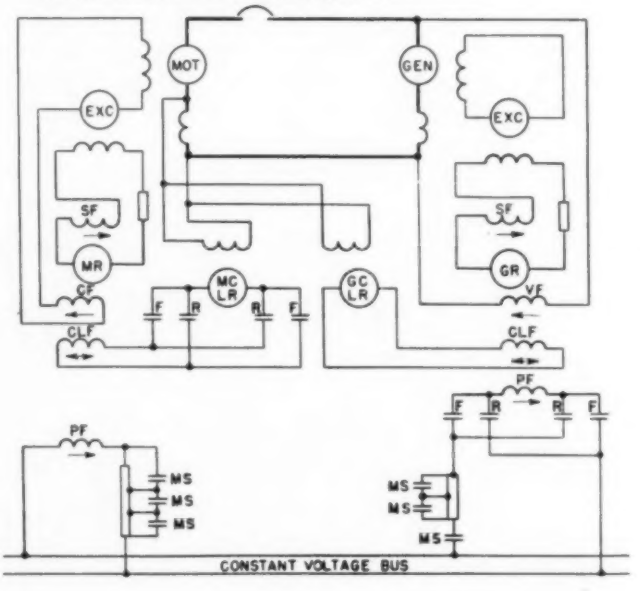
The rising output has been brought about by better utilization of existing apparatus, by constant improvements in ingot heating and mill equipment, and by major improvements in electrical equipment for main drives and auxiliaries. By 1916 when the electrification of the steel industry was only well started, the mill builders were far advanced in their development of blooming mills because of years of experience with steam drives. Because of this experience, the basic design of the mill has changed very little.

When the first electric drive was built for a reversing mill, the designers had a fair idea of the maximum torques which existing engines could exert. Tonnage records and rolling schedules also were available from which some approximate calculations of continuous horsepower requirements could be made. However, practically all the engines of that time had very low torque by present day standards. So no one had an adequate conception of the tonnages which could be produced if the drafts were increased to the capacity of the mill.

The engine builders had been accustomed to thinking in terms of indicated horsepower. Since the horsepower was based on the maximum speed, the ratings of some of the engines of that time were quite impressive. However, when the horsepower ratings were converted to torque the figures were less impressive. For example, the maximum torque of an engine rated at 20,000 hp, 150 rpm, is only 700,000 pounds feet or about what would now be applied to a 30-in. mill. Most of the engines had been designed for rolling small ingots. Production of 50 small ingots per hour was possible, so excellent tonnages were obtained considering the size of the ingots and the amount of draft which could be taken.

To an electrical engineer, a motor is a device for producing torque and the horsepower rating is only a convenient means for indicating the continuous capacity at the desired speed. It had been observed that when

Figure 1 — Simplified schematic diagram of control of main circuits on blooming mill.



an engine reached its limit, it would stall without any damage to itself. On the other hand, it was appreciated that a d-c motor with its 2 to 1 range in torque by field control and its overload capacity would carry any load that was imposed on it up to the circuit breaker setting or the flashover point. So the electrical designers were confronted with the problem of providing a satisfactory reversing drive with a margin of torque for protection. In the first reversing blooming mill drive, the designer's first considerations were mechanical strength and overload capacity, and as a result he provided about twice the maximum torque capacity of engines in current use for the same service. Due to the limitations of the existing engines, no one knew the real possibilities for tonnage from a given size of reversing mill.

The electrical designers soon discovered that they had provided ample torque but that in some cases, they were shy of continuous capacity. When the rollers

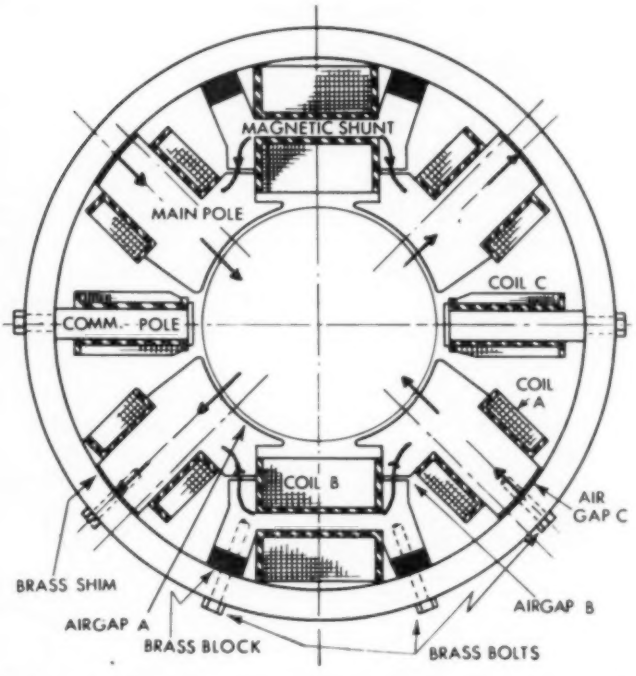


Figure 2 — Construction of current limit exciter is given by this sketch.

discovered that the electrical equipment could be overloaded they gleefully began to take heavier drafts and fewer passes. The usual rolling procedure was to start off with the pits full of hot ingots, turn high pressure air into the auxiliary motors, and roll as fast as possible until all the hot steel plus some not overly hot was finished. Blooming mill tonnages went up. Likewise, the temperature rise of the electrical equipment went up and for a time there was a brisk traffic in spare armatures and rebuilt armatures. So for several years, there was a race between the designers and the rollers. Field tests were made to determine the relation of thermal load to mill tonnage and elongation, and for a time, a thermal ammeter was supplied with every reversing mill drive. By gradual increases in continuous capacity and improvements in the control, the electrical designers finally took a permanent lead. Excess heating of reversing mill drives is now practically unknown.

The net result of this friendly competition has been a large increase in the tonnage of blooms and slabs

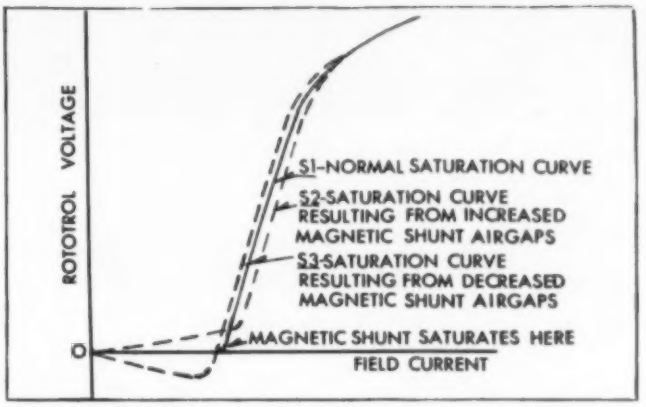

ROTOTROL VOLTAGE
S1-NORMAL SATURATION CURVE
S2-SATURATION CURVE RESULTING FROM INCREASED MAGNETIC SHUNT AIRGAPS
S3-SATURATION CURVE RESULTING FROM DECREASED MAGNETIC SHUNT AIRGAPS
MAGNETIC SHUNT SATURATES HERE
O
FIELD CURRENT

Figure 3 — The characteristics of the current limit exciter are given by the graph.

with no corresponding increase in the number of primary mills.

In the beginning, about 2000 hp at 40 rpm was the maximum capacity which could be obtained from a single armature motor. Mill drives which required more power had two armatures. By gradual improvements in design, the capacity of a single armature was increased to 7000 hp at 50 rpm. The maximum circuit breaker torque for this design is 2,025,000 pounds feet. For a number of years, this was the standard rating for use with 40 and 44-in. mills. The need for high torque, slow speed drives for heavy plate mills brought about the development of a single armature design good for 7000 hp at 35 rpm. The dimensions of the armature are such that it can be shipped anywhere in the U. S. with reasonable care. With suitable windings and commutator, such an armature would be good for 8000 hp at 40 rpm or 10,000 hp at 50 rpm. The maximum circuit breaker torque for either rating would be 2,890,000 pounds feet. By the use of a larger diameter, the capacity could be increased still further; but the shipping range of a complete armature would be extremely limited.

For higher torques such as are required for large slabbing mills, it is necessary to use more than one armature. The greatest amount of power which has so far been applied to a single pair of rolls is 10,000 hp at 40 rpm. A number of twin-motor drives of this rating with 3,600,000 pounds feet maximum circuit breaker torque are in operation. This is about the maximum torque capacity which can be provided in a twin-motor drive with single armatures mounted on reasonable centers. Greater torque and horsepower capacity can be provided either by using one double armature motor or twin drive with four armatures.

So, the electrical design no longer limits the power which can be applied to a reversing mill. Some mechanical problems might arise in designing a pinion stand or a set of twin-motor spindles for torques above five million pounds feet. However, at present, such torques are only of academic interest since none of the existing high torque installations are overloaded.

Because of the slow operating speed and intermittent operation, commutation of large reversing motors has never been a serious problem. With generators, the problem has never been entirely absent. Theoretically, since it is possible to build a single armature motor for

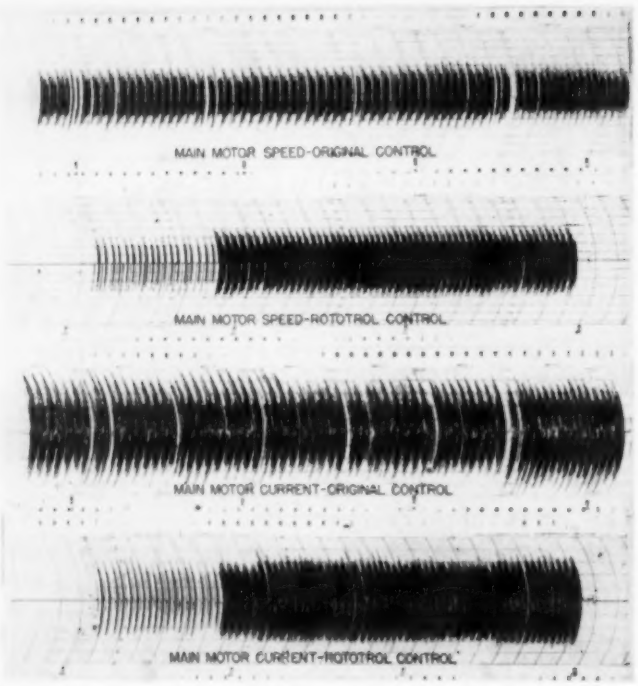

MAIN MOTOR SPEED-ORIGINAL CONTROL
MAIN MOTOR SPEED-ROTOTROL CONTROL
MAIN MOTOR CURRENT-ORIGINAL CONTROL
MAIN MOTOR CURRENT-ROTOTROL CONTROL

Figure 4 — The tests on a 44-in. blooming mill before and after modernization show that rotating regular equipment reduces current peaks.

8000 hp at 50/100 rpm, it should be possible to build a 6500 kw generator with equally good commutation at 100 rpm. While this is no doubt true, it has been necessary for economic reasons to use higher speeds. The efforts of the designers have, therefore, been concentrated on obtaining the maximum capacity at 360 rpm and 514 rpm. On this account, it is necessary to use more than one generator for drives of more than 4000-hp capacity, and it is usually desirable to use two generators down to 2500 hp. Two, three, or four generators can be operated successfully in parallel in reversing service.

The present limits of 3500 kw at 360 rpm and 2000 to 2500 kw at 514 rpm have been set by past experience. Recent experience shows that the performance at these ratings and speeds can be improved by the use of laminated frames.

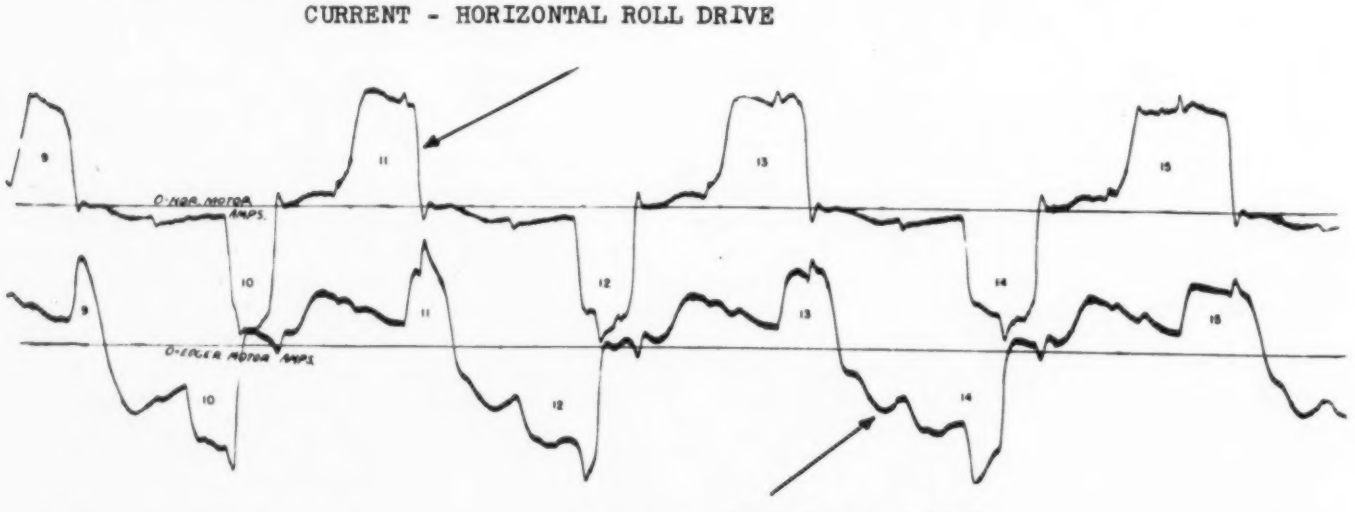
In the early days of rolling mill electrification, the blooming mill usually was a general purpose mill, used for rolling everything from large rounds to 4 × 4-in. blooms. Under present tonnage conditions, the tendency is to have two or more bloomers and to roll a limited range of products in each mill. The new blooming, bar and billet mill installation at the Lorain works of the National Tube Co. is an excellent example of the present tendency for specialization. This installation consists of a 46-in bloomer and a 36-in. bar mill operating in tandem, and followed by two tandem billet mills. The complete installation is designed to produce sections ranging all the way from the smallest commercial billets to the largest blooms. Each unit in the installation rolls a definite range of sizes.

Such sharp division of rolling work tends to simplify both the operation and the equipment. An early model electric blooming mill usually had a drive with a low base speed to provide sufficient torque for heavy passes, and a 3 to 1 speed range by field control to provide speed for finishing small blooms. The overall design was a compromise. If the tables and manipulators were heavy, difficulty was encountered in handling light sections in the finishing passes. In addition, reversal of the main drive from high weak field speeds introduced serious electrical problems. If the mechanical equipment was light, heavy sections had to be handled carefully if excessive maintenance was to be avoided.

Under present conditions, the mechanical equipment and the speed of the main drive can be selected for a particular duty cycle. For heavy mills, the speed may be as low as 40/80 rpm, and for light mills a speed of 60/120 rpm can be used to advantage. This simplifies the electrical equipment for the main drive and table drives.

Within the last four years, fourteen reversing blooming mill equipments have been purchased in this country for installation in the U. S. and abroad. Three of the mills involved are so small that there could not be much reason for using anything other than a stand-

Figure 5 — Edger motors are heavily compounded so that the speed will change quickly to compensate for errors in the original speed adjustment.



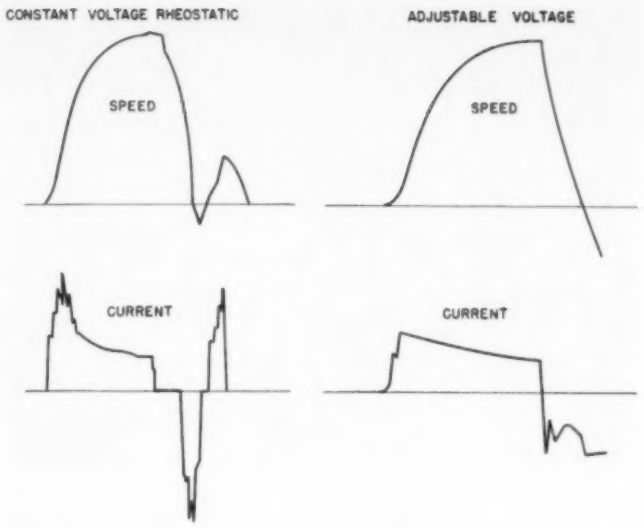


Figure 6 — Adjustable voltage on this screwdown drive has reduced current variation very markedly as is shown by the comparison of the current curve on the left with that on the right.

ard pinion drive. For seven of the eleven remaining mills, twin-motor drives have been chosen. Mill sizes range from 36 to 46-in. and the ratings of the drives vary from 5000 to 8000 hp. This is a definite departure from previous practice under which twin drives had not been used when the required capacity was less than 10,000 hp.

The design of the field control of a reversing equipment has always had as much to do with the operation as any other factor. The old style constant voltage control system with contactors operating directly in the field circuits could be tuned to give very snappy action. However, sharp tuning usually was obtained at the expense of poorer commutation and greater control maintenance. About twenty years ago, the use of a separate adjustable voltage exciter for each field circuit was introduced in this country to reduce the current handled by the contactors. This reduced control maintenance and improved the overall operation. The more recent use of rotating regulators to replace relays for the automatic control features has resulted in further improvement. The chief advantages of the latest type of field control are the improved control of current peaks and reduced commutator maintenance.

Figure 1 is a schematic diagram of a modern reversing mill control with rotating regulators to provide the automatic features. The generator and reversing motor each have one shunt field and each field is supplied by an adjustable voltage exciter. Each of the exciters is regulated by a rotating regulator which the operator can control by means of the main master switch.

The excitation system for the generator is a simple voltage regulator which maintains the voltage according to the position of the master switch and forces the generator field to give quick response when the position of the master switch is changed.

The excitation system for the reversing motor maintains the motor field current according to the position of the master switch and also gives quick changes in field current when the position of the master switch is changed. The operation of the motor excitation system is modified automatically by the action of a current limit exciter. This exciter acts to increase the strength of the motor field when the motor armature current exceeds a predetermined value.

The construction and characteristics of the current limit exciter are shown in Figures 2 and 3. Between each pair of main poles, there is a magnetic shunt, excited by coil B. Coils A on the main poles and coils B are in series and are connected across the interpole and compensating windings of the reversing motor. As long as the magnetic shunt is unsaturated, little or no flux will pass through the main pole air gaps and no voltage will be generated in the armature. As the shunt saturates, the flux is forced through the main pole air gaps and the armature voltage rises rapidly. The slope of the resultant saturation curve before the sharp rise can be changed by adjusting the air gaps in the magnetic shunt. The normal adjustment provides a slight rise, thus giving a slight compounding effect. This and the fast action of the machine usually makes it unnecessary to have a series exciter for compounding.

Figure 4 gives a comparison of the performance on the same mill of a constant voltage control system of early design and a recent system with rotating regulators. It will be noted that the average speed is higher and the current peaks are lower.

A present day reversing equipment will have the following main features which were not found in similar equipment fifteen or twenty years ago.

Dynamic braking for bringing the flywheel set to rest.

Oil lift for the flywheel bearings to prevent damage to the bearings when starting after a prolonged shut down.

Total enclosure and forced ventilation for all main machines.

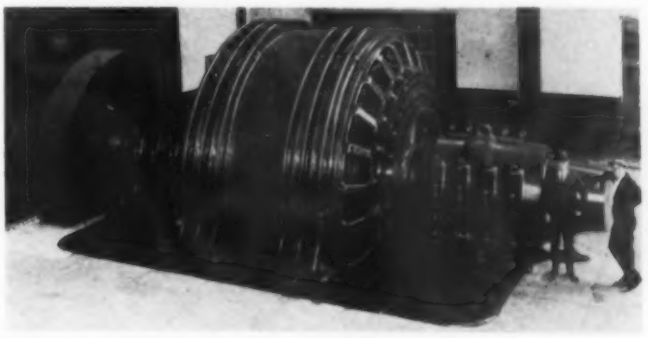
Laminated frames for the generators.

Rotating regulators for automatic control features.

One of the serious problems which arises in the design of a universal slabbing mill is the selection of the means for doing the edging. The edging may be done in a separate stand which works entirely independent of the main rolls. Or the edging rolls may be located as closely as possible to the horizontal rolls so that the slab is in both sets of rolls for a considerable part of the rolling time.

The choice of arrangement depends upon the type of work to be done. When it is desired to make spreading

Figure 7 — This motor, built in 1923, is the last completely new double-armature 7000-hp, 50/120 rpm reversing mill drive built in the U. S. Except for special cases, single armature and/or twin drive construction has been used since that time for all ratings. Ratings up to 7000 hp at 35 rpm, equivalent in torque to 10,000 hp at 50 rpm, have been built in a single armature.



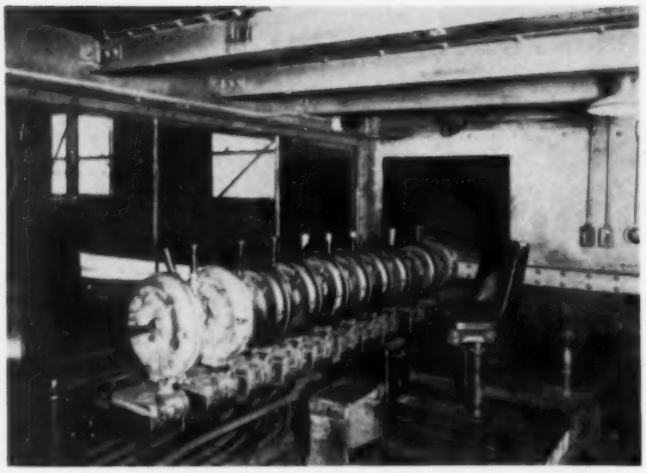


Figure 8 — Pulpit of a 40-in. blooming mill, built in 1923, one of the first pulpits to have a chair for the roller. This pulpit was unusually spacious for its time.

Figure 9 — Auxiliary control for a 40-in. blooming mill built in 1923. An unusually good arrangement of rheostatic control with spare panels and transfer switches.

passes in the horizontal rolls to make slabs which are wider than the original ingot, the vertical rolls serve chiefly as a means for squaring the edges and holding width. For this condition, it will be most satisfactory to have the edging rolls at some distance from the horizontal rolls. When the width of the finished slab is always less than the width of the ingot, it is necessary to do some edging work in practically every pass. Then it is desirable to have the vertical rolls as close as possible to the horizontal rolls. This type of mill has high lift for the top horizontal roll and edging passes are made in both sets of rolls.

When the edging stand is entirely separate from the horizontal rolls, the drive can be designed to do its work without any consideration of speed relations with the main rolls. Since it is not necessary to compensate for variations in roll diameters, and for draft in the main rolls, the speed range can be the same or less than that of the main drive. The amount of power used depends entirely on the rate at which it is desired to do the edging work. A typical installation of this type has a 2000-hp reversing motor with 2 to 1 speed range. The edging roll motor is supplied from the same generators as the main roll drive. The edging roll drive runs idle when the main rolls are working and the main roll drive idles when the edger is working, so no additional generator capacity is required for the edger.

When the edging rolls are close to the horizontal rolls and the two sets of rolls run approximately in synchronism, the duty on the edging rolls and drive is much greater. The speed range must be wide enough to cover the operating range of the main rolls plus an allowance for compensation for horizontal roll draft and variations in roll diameter. A 3 to 1 speed range is usually required to cover all these conditions. The factor which limits the amount of power which can be used in the strength of the right angle gear drives. Up to the present time, 3000 hp is the maximum power which has been used.

Compensation for roll diameter is a positive adjustment which is made only infrequently. Compensation for draft in the horizontal rolls is an indefinite matter since the percentage reduction varies with every pass. This is done by reducing the speed of the edging rolls by a fixed percentage for the passes in which the slab enters the vertical rolls first. The reduction in speed in this direction is approximately proportional to the average draft. The edger motor is heavily compounded so that its speed will change quickly to compensate for errors in the original speed adjustment.

The manner in which this works is shown by Figure 5. This figure is a section of an oscillogram which was made when rolling a 29 × 55-in. ingot to a slab 6 × 40 in. For the odd numbered passes, the metal enters the horizontal rolls first and for the even numbered passes, the metal enters the vertical rolls first. In Pass 9, the slab just clears the horizontal rolls as it enters the vertical rolls. In the succeeding passes, the loads overlap for increasing periods of time. In Passes 11, 13, and 15, each drive takes its share of the load under all conditions. In Passes 10, 12, and 14, the edger motor is set to be slightly fast for the draft being taken in the horizontal rolls. As shown by the loads for Pass 14, the edger motor starts the pass with more than its share of the load. The droop of the edger motor rapidly reduces the load on the vertical rolls and transfers it to the horizontal rolls.

Developments in auxiliary drives have also contributed to the progress which has been made in blooming mills and slabbing mills. The general tendency for new installations has been to use adjustable voltage for all the auxiliaries except the manipulator fingers. However, some of the latest European mills will have adjustable voltage control for the manipulator fingers. The chief overall advantage of adjustable voltage control is of course the reduced maintenance. Probably next is the increased screwdown speed which can be obtained for long screw movements with no sacrifice in accuracy for short movements. The soft yet speedy action of the manipulator side guards is another advantage. A number of old auxiliary control installations have been changed to adjustable voltage to improve the overall performance of the mill. Our corporation alone has supplied 198 adjustable voltage generators for auxiliaries of old and new blooming mills and slabbing mills.

The reason for the reduced maintenance is illustrated by the oscillograph curves in Figure 6.

The curves in this figure show the armature current

and speed during the acceleration and deceleration of a screwdown with rheostatic control and a screwdown with adjustable voltage control. Both sets of curves are for long movements in which the motor reached top speed. The transient current for the rheostatic control consists of a series of short vicious peaks. Their effect is well known to every maintenance man. On the other hand, the current curve for the adjustable voltage control has no sharp peaks and changes are relatively slow. This results in less electrical and mechanical maintenance.

The operating characteristics of the adjustable voltage system are ideally suited for use in automatic control. Almost any desired degree of refinement can be obtained without the use of armature shunts. Any desired speed can be maintained regardless of the load.

Automatic operation of the screwdown is about the only automatic feature which has been considered for blooming and slabbing mills. The few attempts which have been made along this line have been done with rheostatic control and the maximum results have not been obtained. Usually the use of automatic screwdown equipment is not justified. In any special cases where such control will serve a real purpose, the best results will be obtained with adjustable voltage control.

Since the steel is handled by the auxiliaries from 60 to 75 per cent of the total rolling time, the importance of the auxiliaries cannot be over-estimated. In designing a new installation, it pays to spend considerable time in the study of every detail of the duty cycle of each auxiliary drive. All auxiliaries are geared so someone always has the task of selecting the gear ratio. The natural tendency is on first choice to select ratios which are too low. It is well known but often overlooked that for every combination of equipment and operating conditions, there is an optimum gear ratio which will give the shortest cycle time and probably the least load on the electrical equipment. Numerous instances are on record where an increase in gear ratio of a table drive or an ingot car drive reduced the cycle time and reduced the heating of the motors. In the early installations, the auxiliary motors often were too small and were a continual source of trouble. The use of high pressure air for cooling was an expensive and probably equally ineffective way of increasing the capacity. The present tendency is to use motors of ample capacity and provide them with forced ventilation, so the principal concern is to make sure that they are utilized to the best advantage. Time studies of the operation has in many cases resulted in marked increases in mill output.

A large part of the increase in blooming mill tonnage capacity in this country has been obtained by improving existing equipment and rolling practice. A brief review of the history of some of the older installations will indicate some of the steps by which improvement has been obtained.

The first reversing equipment purchased in this country for blooming mill drive was a double armature unit for a 35-in. mill. The drive was purchased in 1913, but due to business conditions did not go into operation until October, 1915. The installation was designed to roll 19 × 23 × 96-in. ingots to 8 × 8 in. and 19 × 16 × 76-in. ingots to 4 × 4 in. and intermediate sizes. The reversing motor had a continuous rating of 3600 hp, 40/120 rpm and a maximum torque of 1,500,000 pounds feet with full field. The master switch had 16 speed control points. Between 1915 and 1948, the field control was replaced twice to take advantage of improvements in reversing mill control and the number of speed control steps was reduced from 16 to 6. The control for the main tables was changed so that they are controlled by the master switch for the mill drive and so that the table on the delivery side is normally dead, and the table on the entry side runs only while the main roll motor is operating at full field. The control for the auxiliaries is still rheostatic, but the control panels have been completely replaced. The armatures of the reversing motor were rebuilt to increase the continuous capacity up to present-day standards.

In 1948, the complete equipment was given a major overhaul. The tables, screwdown, and manipulator were rebuilt. Rolls of larger diameter were provided for the mill. The armatures of the main generators were rebuilt for 45 per cent greater capacity and the induction motor was rewound. A new ventilating system with coolers was installed. A new field control of the latest design was installed. New a-c primary control with

Figure 10 — External view of the pulpit for a recent 46-in. blooming mill.

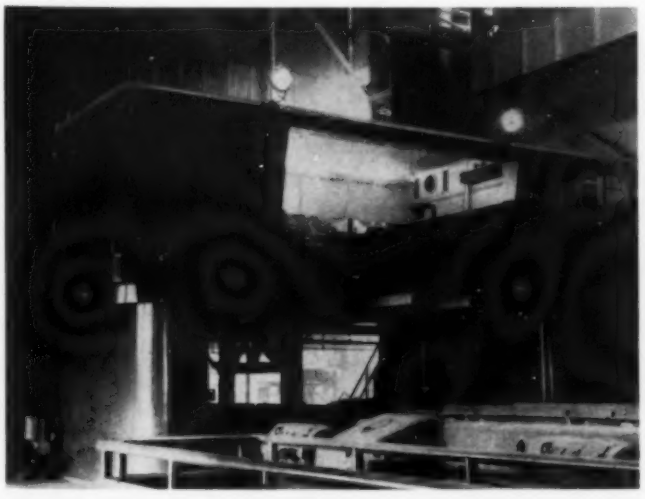


Figure 11 — Internal view of the pulpit for a recent 46-in. blooming mill shows a neat and compact arrangement.

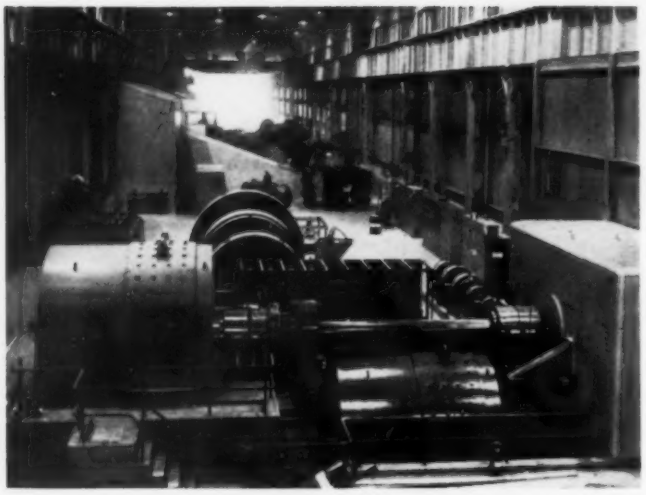


Figure 12 — An 8000-hp, 40/80 rpm twin-motor drive for a recent 46-in. blooming mill.

differential relays and dynamic braking replaced the old plugging control for the flywheel set. So now after almost 35 years of service, the mill and the electrical equipment are in better shape than ever. The mill now rolls heavier ingots with heavier drafts, and the tonnage capacity is the greatest it has ever been.

The first drive ordered for a 40-in. reversing mill was purchased in 1915 and went into operation early in 1917. This mill was provided with ample pit capacity and could operate continuously at a steady rate. By the time this equipment was installed, experience had already shown the necessity for greater thermal capacity in the armature of the reversing motor. Therefore, the original double armature was replaced as quickly as possible with a new armature of about the same capacity as would be used today. Using this armature and the original generators and control, a record of 90,000 short tons of ingots was established for one month in 1924. New generators of larger capacity were installed in 1926. In 1927, the maximum output for one month went to 117,000 short tons of ingots under slightly harder rolling conditions.

Among the early reversing equipments with approximately present-day thermal capacity is a double armature drive for a 44-in. blooming mill. This equipment was ordered in 1919 and went into operation early in 1921. The soaking pit capacity was such that the mill could roll comfortably 60,000 to 70,000 short tons of ingots per month. The equipment ran until 1944 with no changes except that the original slip regulator was replaced with a home made regulator of ingenious design. In 1944 some new soaking pits and a new ingot buggy were installed. At the same time the original field control was replaced with control of the latest type. About 20 per cent greater tonnage can now be rolled with less stress and maintenance on the equipment. Recent studies have shown that some further improvement can be obtained by speeding up the screwdown.

The tonnage capacity of many other old blooming mill installations could be increased by replacing any parts which may be limiting the output. New generators of greater capacity and with better performance can often be installed with very little change in the bedplate and foundation of the flywheel set. If the induction motor is the bottle-neck, a larger motor usually can be provided. If the field control is very old, new exciters and field control will reduce maintenance of control and commutators and will speed up the operation. If any of the auxiliaries are too slow, a change in gear ratio or a change in the drive or control may be helpful.

Some of the existing steam driven mills are in good mechanical condition, but have a high operating cost due to the high cost of fuel and the standby losses and maintenance costs of the steam equipment. Electrification of the main drive will give a decided reduction in operating cost and may increase the tonnage capacity.

The time for the changeover from steam to electric drive will depend on the space available. In some cases, the pinion stand and motor room can be located on the side opposite to the engine. The electrical equipment and foundation for the pinion stand (if used) can be installed completely and checked before the engine is taken out of service. The mill will be out of service only for the time required to move the pinion stand, couplings and spindles to the opposite side of the mill. When the reversing motor must be located in the space occupied by the engine, the flywheel set, switchgear and control are installed and the engine foundations are uncovered for demolition while the engine is still in use. The record time for removing the engine and installing the motor ready for operation is 129 hours. In some cases where the pinion stand and spindles were retained without change, the motor was installed as close as possible to the end of the engine crankshaft. The crankshaft was then replaced with a jackshaft made to fit the engine bearings. The downtime for such a changeover can be quite short.

With the background of experience which is now available the selection of the drive for either a new mill or an old mill is not difficult. The performance of existing installations is always an excellent practical guide. Where known conditions or anticipated future conditions are severe, there is a present tendency to provide greater capacity than was used a few years ago. For example, some of the latest 45 and 46-in. mills have 8000-hp main drives rather than the 7000-hp capacity often used in the past. Load calculations can be helpful in the selection of the maximum torque, speed range

Figure 13 — Motor-generators for the adjustable voltage auxiliaries of a recent 46-in. blooming mill. The d-c control is in the background.

and continuous rating, and in the determination of the probable maximum output. Methods of making such studies have been given in previous papers so there is no need to repeat them here. Because of the importance of the auxiliaries, the mill builders tend to use auxiliary motors of ample capacity so their recommendations can be accepted with confidence.

The maximum peaks drawn by the main drive from the a-c line do not need to exceed one kilowatt per rated horsepower of the motor which drives the flywheel set. For a light 35-in. mill, the slip regulator can be set at 2500 to 3000 kw; for 40 to 44-in. mills, 4000 to 5000 kw; and for heavy 46-in. mills, 5000 to 6000 kw.

The energy consumption depends upon the rate of rolling and the elongation. The kilowatt hours per short ton of ingots for the main drive exciters and ventilating fans for average rolling conditions are as follows:

Elongation	*Kwhr*
7½	12.5
10	15.5
15	19.0
20	22.0
25	24.0

Due to the losses in the flywheel set, slip regulator, excitation system and ventilating system, the reversing equipment is not, purely from the electrical standpoint, the most efficient type of drive in the steel industry. Nevertheless, the total energy consumption per ton is quite low. Also, in spite of the relatively small amount of rolling work done in the bloomer, electric drive is by far the most efficient form of drive.

The blooming mill, as a type of mill, has persisted in its general form longer than many other types of mills, and therefore the development has been gradual rather than spectacular. However, because of its reliability and flexibility, and the neat and workmanlike manner in which it performs its work, the blooming mill is one of the most satisfactory pieces of equipment used by the steel industry. It has kept in step with the times and can take care of all foreseeable future demands. Truly the blooming mill is the steel industry's faithful iron work horse.

DISCUSSION

PRESENTED BY

A. MALONE, Electrical Engineering Department, Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.

H. H. ANGEL, Electrical Engineer, Construction and Engineering Department, Bethlehem Steel Co., Bethlehem, Pa.

M. B. ANTRIM, Superintendent Electrical Maintenance, Lukens Steel Co., Coatesville, Pa.

L. V. BLACK, Superintendent Electrical Department, Bethlehem Steel Co., Bethlehem, Pa.

A. D. HOWRY, Assistant Superintendent of Maintenance, Alan Wood Steel Co., Conshohocken, Pa.

ROBERT McDANEL, Bethlehem Steel Co., Steelton, Pa.

R. H. WRIGHT, Industry Engineering Department, Westinghouse Electric Corp., East Pittsburgh, Pa.

A. Malone: Mr. Wright has presented an interesting narrative of the early history of the blooming mill, tracing it down two quarters of the present century. The Fairfield Steel Works have two electric driven blooming mills which are good examples of the old and new, namely No. 1 and No. 2.

No. 1 was built in the year 1918 and among the first of its type built in this country. It is a good example of liberality of the early electrical designers. The main drive motor has a double armature and is rated at 5600 hp at 35 C. Its motor-generator set consists of a 4000-hp, 6600-v, 60-cycle, induction motor, with liquid slip regulator, driving three 2000-kw, 600-v, d-c 35 C generators and a 100,000 pound flywheel. The main drive motor control is a "Ward-Leonard" type for that period, all generator and motor armatures being connected in series. All auxiliaries are driven by standard 230-v d-c mill type motors with constant potential magnetic control.

This mill has been in operation 32 years with very reasonable maintenance cost. The only major repairs to the main drive has been rewinding the armature three years ago and replacing about half of the shunt field coils at the same time. This major repair was a planned job and was not due to a major breakdown. Advantage was taken of the time the mill was down to install new reversing tables.

No. 2 blooming mill was built in the year 1939. It is a more modern installation in every way. It is more rugged and faster than the old mill. It is used exclusive for the production of large slabs. The main drives, screwdowns, front and back tables are Ward-Leonard controlled. Auxiliary equipment used in this mill was described by W. B. Snyder in the 1937 Proceedings of the Association of Iron and Steel Engineers, p186.

In concluding, some unique features of both mills may be mentioned:

1. Ingots are manipulated on the front or entry side only.
2. The load spindle is provided with "breaker bolt" coupling.
3. Selsyn generators are installed on the motor shaft and on the pinion. They are connected through a differential selsyn to the breaker so that an angular difference of 30 degrees between the motor shaft and pinion will open the main circuit breaker.

H. H. Angel: I want to mention that in spite of the fact that the tonnage has been increased, due to the better control on the reversing drives, etc., one of the biggest features to further increase production is to make the auxiliary equipment function faster. For example, a lot of time is lost in the manipulation of the screwdowns as well as the manipulator side-guards, and the manipulator fingers.

I personally have not had any experience with the rotating control on blooming mill drives. My experience has been limited to the old controls, where you attempt

to make the acceleration and deceleration as fast as possible and keep within the commutating limits. I can readily see where the rotating control has almost performed miracles in providing faster time in accelerating and decelerating, and in limiting the current peaks so that the generators will not arc or reduce the life of the brushes.

M. B. Antrim: I realize every plant has its own rolling problems. We, at Lukens, roll directly from the ingot to the plate. That presents some peculiar difficulties, as far as the determination of correct horsepower to put on mills is concerned, for this reason:

The operating department selects a percentage of screwdown, which depends upon the thickness of the ingot when it starts into the mill. This is in general a decreasing percentage as the steel becomes thinner, and finally, as the plate is finished. During this process, it is necessary that we turn the ingot 90 degrees, and roll it a number of times, to obtain the correct width to which we are going to finish our plate.

When the operator starts to roll the ingot, he selects a fairly heavy percentage of screwdown and keeps rolling down and breaking off the scale using this same amount of screwdown. After this the steel is turned 90 degrees. The ingot is longer, of course, than it is wide, and when the same amount of screwdown is used to roll it the wide way, we really get a peak on the drive. We are engaged in the electrification of the 206-in. mill. We have run into the peculiar circumstance which was mentioned by Mr. Wright, in that we had a steam engine driving this mill for the last thirty years, which operated at a top speed of 60 rpm. Therefore, when we selected the motor drive we tried to maintain a torque equal to the steam engine at its top speed. It so happened when we decreased the speed to 30 rpm with the motor selected which will be an 8000 hp d-c reversing mill motor, the torque far exceeds the strength of the pinion stand on the mill. We were, therefore, forced to go to a twin drive plate mill, using two 4000 hp at 30 to 75 rpm reversing mill motors. In other words, since the steam engine put out a certain torque at 60 rpm and we selected the motor on that basis, when we slowed the motor to 30 rpm, we obtained a much greater torque than the pinion stand could take and we had to do away with the pinion stand.

I would like Mr. Wright to comment on the possible effects that the inclusion of rotating control on any mill might have, in reference to the commutating ability of the generators which he mentioned were the weak point in mill drives, due to the speed at which they must run.

L. V. Black: An interesting point in Mr. Wright's paper was that most of the blooming mills today roll 8 × 9 or 8 × 8-in. blooms. Bethlehem still rolls a sizable quantity of 4 × 4-in. blooms to go directly to an 18-in. mill for further reduction. Bethlehem's mill was put in service in 1915 and operated satisfactorily for 25 years after which the armature became loose on the shaft. At that time it was decided to replace the double armature with an armature which would be a spare for any one of five locations in the Bethlehem corporation; namely, mills at Sparrows Point, Steelton, Bethlehem or Lackawanna. It is stored on a special car and held in readiness at all times for a change or a break-down. The armature weighs approximately 92 tons. The car with the double armature and protecting house is so built and equipped with heaters and air-conditioning that it is available at a moment's notice.

The new armature was put in the Bethlehem mill on Christmas 1941. In May of 1942 a flood of the Lehigh River drowned that armature and considerable time was required to dry it. It is now operating very satisfactorily.

Last year it was decided to replace the rest of the electrical equipment on the mill. The commutators on the double armatures of the flywheel motor-generator set had been previously redressed to their minimum safe operating diameter, and accordingly the flywheel motor-generator set was completely rebuilt, and all new fields were installed in the mill reversing drive motor. At this same time rotating regulator control was installed to replace the previous rheostatic control.

Since these changes, the mill has operated satisfactorily with somewhat increased production.

A. D. Howry: We have a reversing electric drive on our 35-in. blooming mill operating for the best part of five years. This unit is rated 3500 hp, and has given us exceptional service, the delays have been minor, and very infrequent. The reversing motor commutation is perfect with approximately 60 per cent of the original brushes still in service.

The two 1500-kw generators originally showed slight burning at the trailing edges of the commutator bars; at the recommendation of Mr. Wright, the brushes were changed to a semi-high altitude type, which has corrected this condition.

Mr. Wright stressed the high speed operating characteristics of the rotating regulator. Our mill is not so equipped, and I am wondering whether we would be justified in making this addition, considering the diversified product we roll on our bloomer.

Robert McDanel: The rotating regulator control at Steelton is a great improvement over our old control, which was put in service in January 1921. The rotating regulator was installed in March 1946 and to date has been trouble-free. The commutation is greatly improved and the maintenance is much less than on our old control. It is a great improvement.

R. H. Wright: Mr. Angel and Mr. Antrim have asked how the use of modern reversing mill control affects generator commutation. In general, anything which reduces the sharpness of transient current peaks is an aid to commutation. A reversing mill control with adjustable voltage exciters and rotating regulators seems to do this. Current peaks during reversals are more smooth and of lower magnitude and load peaks are kept under better control. The latter feature will be the one of most interest to Mr. Antrim in his new plate mill drive since the reversal peaks in a slow speed twin-motor drive are quite low.

The equipment which Mr. Howry mentioned has adjustable voltage exciters with relays for automatic control features. Some minor improvement in performance and some reduction in maintenance might be obtained by substituting rotating regulators for automatic relays. However, the improvement would not be nearly as pronounced as when an old style constant voltage control is completely replaced with the latest type of control. The experience of Mr. Black and Mr. McDanel is typical of such cases.

TELEVISION IN INDUSTRY

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Diamond Power Specialty Corp.
Lancaster, Ohio

. . . . there are many possible applications in the steel plant where industrial television may effect better operation or help to cut costs . . . .

▲ Is industry keeping up with the times?

The heritage of American industrial progress was brought about by the application of ideas of ambitious personnel. A question being raised these days: "Is television ready to take its place along with other developments such as the telegraph and telephone, etc.?" Industry did not look too favorably on the telegraph and telephone when they were first introduced, but today, we are safe in saying, progress would be materially reduced if we had to do without them. In answer to the question "Is television ready to take its rightful place," we feel it is. This is especially true in the power plant industry where the use of television has become a necessary piece of operating equipment.

It was the power plant field that cemented the foundation for the development and application of industrial television as we see it. The background for this undertaking is that, in recent years, the demand for power has, and still is, increasing; thus demanding larger steam output from boilers. Since the cost per square foot of land is very high in our larger cities, and because of increasing labor costs, the natural tendency was to build these boilers six or more stories high. This condition immediately gave rise to supplying instruments and controls to cope with their operation. In using boilers of this kind, it is very important that the water level in the drums, which are located in the top of the boilers, be watched and maintained very closely. Boilers of present day design have very little water storage capacity, and, in a matter of seconds, could easily be emptied, if it were not for adequate control. Due to economic reasons, it is necessary to operate these boilers twenty-four hours a day, three hundred and sixty days a year.

In the Spring of 1945, a large central station in the Southeastern part of the United States had a very serious and expensive boiler accident due to "no water." Two different styles of water level indicating equipment on the control board showed there was water in the boiler when in reality there was none. This same accident was repeated in Southern Illinois in September of 1947. In industry, we have found there are many other needs, aside from water level indicators, for transmitting information from one point to the other without the slightest possibility of error. The fundamental requirements of such systems are:

1. It will either show a correct reading or no reading at all.
2. It must be viewed through a wide angle of vision.
3. The equipment must operate twenty-four hours a day, seven days a week.
4. The cost, original and maintenance, must be in line with its value.
5. It must have no mechanical or moving parts.

Investigation further showed that, for short distances of transmission, a simple mirror system will meet these five requirements. However, where transmission distances exceed 100 ft, or where obstructions necessitate using several mirrors with images in several planes, simple wired television fulfills the basic requirements to the best advantage.

In applying successfully any instrument or appliance to industry, many design factors have to be considered, such as operating conditions, heat, cold, dust, dirt, humidity, personnel handling such equipment — will it be handled by skilled technicians, or ordinary factory help such as a plant electrician, mechanic, or carpenter? Many good ideas conceived in an air-conditioned laboratory, and in the hands of expert technicians, have met with complete failure in the field because field conditions had not been considered. The components that are selected to go into an over-all design have to be given careful consideration from an engineering and operating standpoint. It can easily be seen that a component might be designed to run at ordinary room temperatures, but in industry it may be subjected to abnormal conditions. Operating conditions were carefully considered when our organization undertook the development of a simple, stable and reliable television system.

Television is probably the most advanced form of communication as far as relaying exact information is concerned. The fundamental object of communication is to get information from one point to another. The form that the equipment takes to accomplish this is determined by physical conditions that exist, together with the rate of transmission desired. How many of us stop to consider the number of words required to adequately portray a picture that can be transmitted by television in a fraction of a second? Visual aids in industry and education are becoming more prevalent as time goes on.

The need for getting information from one point to another determines the amount of money that can be spent to accomplish this. The cost of equipment must be met by the savings measured in human safety or dollars. The accessibility of the information or capital required to make the information accessible should also be considered.

Many persons today think of television as a complicated and secret development. There is justification for this reasoning when we consider the number of ordinary radio tubes required to get a picture from a television camera in a studio to your home. This number is between 750 to 1000, and requires warm-up time and many technicians to make it function properly.

World War II saw some attempts to apply television to industrial use. Such systems were used by the military and required between 35 and 50 tubes, and were designed to operate very short periods of time. Such equipment, by its very nature, could not be used successfully in industry. It did serve as a basis for development. Starting with this information, our organization set out to explore the limits of simplicity, reliability, and stability, at the same time keeping in mind maintenance, type of personnel handling the equipment, and operating conditions in general.

Figure 1 shows the equipment in its final form. The following tabulation covers much of the general and technical information on the equipment:

GENERAL

1. *Number of units* (3)
   Camera pickup.
   Camera power (sending end).
   Monitor (receiving end).
2. *Maximum separation between units.*
   Camera pickup unit to camera power unit — 100 feet (Single 17 conductor interconnecting cable).
   Sending end to receiving end — 1000 feet (Three RG62U connecting cables).
3. *Operation.*
   Continuous or intermittent.
4. *Maximum ambient temperature.*
   Camera pickup and camera power unit — 65 C.
   Monitor — 50 C.
5. *Lens.*
   F/1.4 (coated) — 90mm focal length.
   Focus adjustment 20 inches through infinity (See Figure 2 for lens object distance).
6. *Illumination Required.*
   Minimum object illumination required, about 300 foot candles of sunlight, or 2870 degree Kelvin tungsten-lamp light.
7. *Power requirements*
   Nominal 115 volt a-c (60 cycle only).
   Camera power — 100 watts.
   Monitor power — 125 watts.
8. *All controls available from the front.*
   (Except clipping level control and camera width-control).
9. *Available controls.*
   Camera pickup unit — None.
   Camera power unit — None.
   Monitor unit — Three.
   a. Focus.
   b. Brilliance.
   c. Contrast.
   Monitor remote control of camera — Four.
   a. Lens focus.
   b. Lens shift.
   c. Magnetic focus.
   d. Video over-load.
10. *Pre-set controls.*
    Camera pickup unit — Two.
    a. Scan size (width).
    b. Clipping level.
    Camera power unit — Four.
    a. Height.
    b. Vertical linearity.
    c. Line voltage.

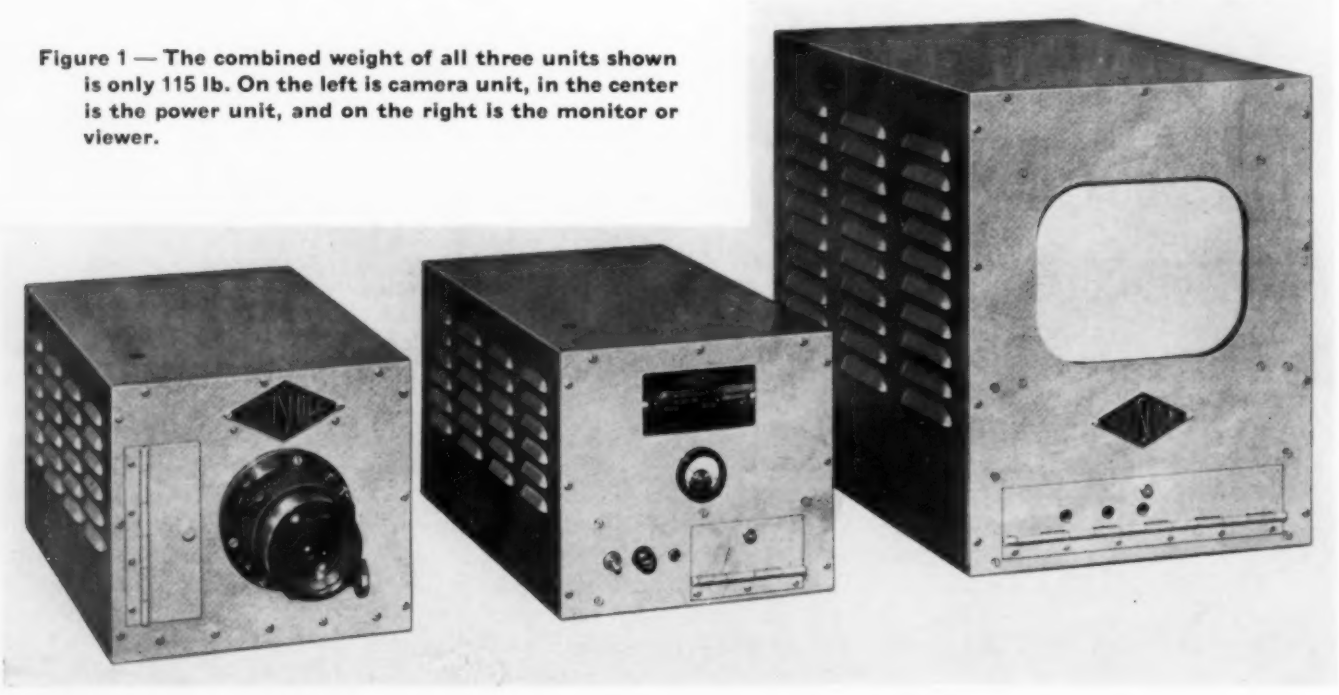


Figure 1 — The combined weight of all three units shown is only 115 lb. On the left is camera unit, in the center is the power unit, and on the right is the monitor or viewer.

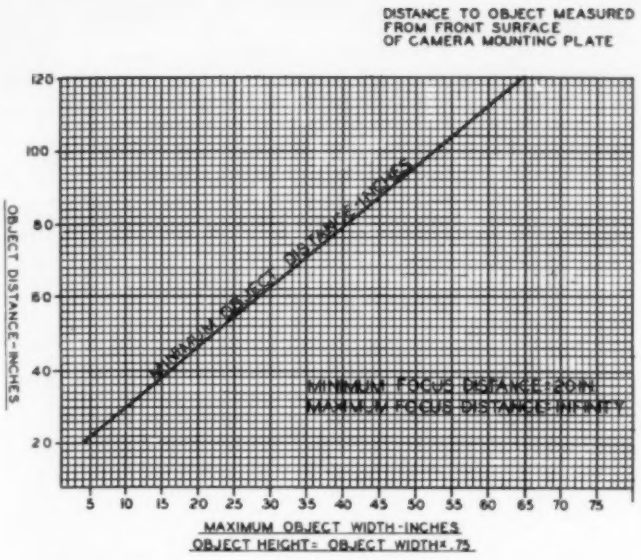

DISTANCE TO OBJECT MEASURED FROM FRONT SURFACE OF CAMERA MOUNTING PLATE
OBJECT DISTANCE-INCHES
MINIMUM OBJECT DISTANCE-INCHES
MINIMUM FOCUS DISTANCE: 20 in.
MAXIMUM FOCUS DISTANCE: INFINITY
MAXIMUM OBJECT WIDTH-INCHES
OBJECT HEIGHT= OBJECT WIDTH×.75

Figure 2 — Chart gives data for focusing camera.

d. Horizontal linearity.

Monitor — Six.

a. Width.
b. Height.
c. Vertical linearity.
d. Horizontal centering.
e. Vertical centering.
f. Horizontal synchronization.

11. *Tube complement — Total seventeen.*

Camera pickup unit — Three.

a. Dissector — One.
b. Receiving tubes — Two.

Camera power unit — Six.

a. Receiving tubes — Four.
b. Rectifiers — Two.

Monitor — Eight.

a. Cathode ray tube — One.
b. Receiving tubes — Five.
c. Rectifiers — Two.

12. *Accessible plug termination on monitor for video line.*
13. *Each power transformer is fused.*

ELECTRICAL SPECIFICATIONS

1. *Direct horizontal and vertical synchronization of monitor.*
2. *Scanning frequencies.*

Horizontal — 21,500 cycles (free running).
Vertical — 60 cycles synchronous with power line frequency.
Non-interlaced.

3. *Aspect-ratio* — 4/3.

Monitor picture width — 8¼ in.
Scanned image on dissector — 2-in. wide nominal; 1⅞ in. minimum.

4. *Resolution (center of picture).*

Horizontal — 300 lines.
Vertical — 300 lines.

5. *Video bandwidth — 4MC.*
6. *Video gain.*

Camera — 2 volts.
Monitor — 80 volts.
From dissector to cathode-ray — 160 volts.

7. *Maximum over-all scanning distortion.*

Horizontal — 15 per cent.
Vertical — 10 per cent.
"S" distortion — 10 per cent.

8. *Design center line voltage* — 115 volts.

Operating line voltage center 105 to 130 volts.

9. *Picture tube anode voltage* — 7500 *volts nominal.*
10. *Dissector multiplier voltage* — 1900 *volts nominal.*

MECHANICAL

1. *Size.*

Camera pickup unit — 9¾ wide × 8½ high × 17½ in. deep.
Camera power unit — 9-2/3 wide × 8½ high × 17½ in. deep.
Monitor — 13 wide × 16⅝ high × 20⅜ in. deep.

2. *Weight.*

Camera pickup unit — 47 lb.
Camera power unit — 37 lb.
Monitor — approximately 60 lb.

3. *Mounting provisions.*

Shock mounts.

4. *Line power input plugs.*

Locking type.

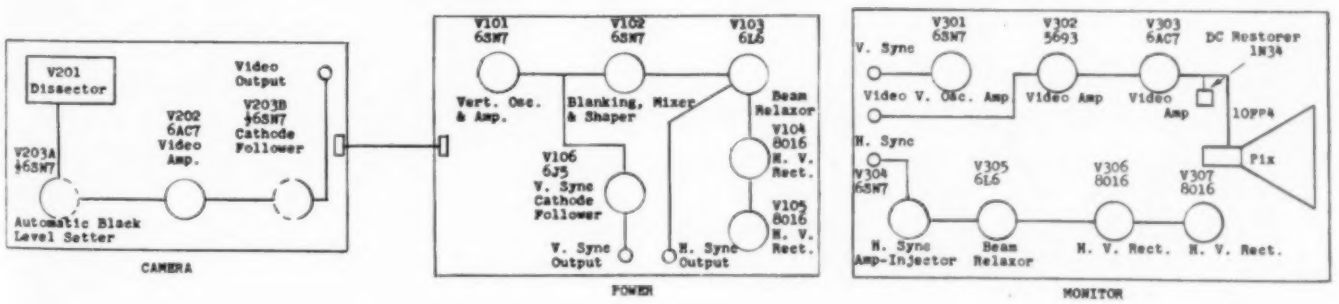
5. *Appearance.*

Rugged and reliable, but cost a major consideration.

PICKUP TUBE

Translucent dissector type — D30LL.

Figure 3 — The block circuit layout of the three component pieces of equipment is given in this diagram.



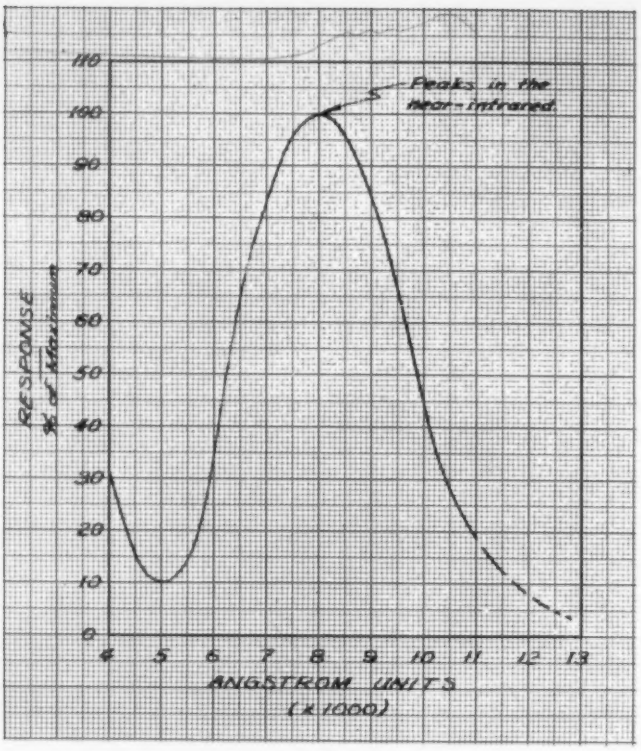


Figure 4 — Curves show spectral response of image dissector tube.

MISCELLANEOUS

1. *Picture tube.*
   Type 10FP4 (Aluminized).

The block-circuit lay-out of the equipment is illustrated by Figure 3.

For simplicity in design and long-life of equipment, the image dissector camera tube was selected as the tube to be used. Although the light requirements are high compared with other camera tubes, the end operating results, in our opinion, more than justify the use of this camera tube. The spectral response of the tube is shown in Figure 4.

No piece of equipment offered to the public will meet with success unless a factory service program is initiated with the equipment. This is especially true with equipment of the television nature. Any concern entering this field will have to provide trained service personnel to answer customer's problems, be they real or imaginary. Service problems encountered by our organization can be exemplified by power failures at a remote point, defective components, and mechanical problems such as the accidental spraying of lens with paint as occurred at one plant.

The following lists in a very brief way applications to which the equipment has been applied:

1. Watching jet engines.
2. Operations in a hospital.
3. Banks for watching statements and signatures.
4. Steel industry.
5. Coal industry.
6. Nuclear research.
7. Power plant industry — gauges and furnaces.
8. Smoke control — watching smoke stacks.
9. Projection microscopes.
10. Production in the automotive industry.
11. Armed forces.

DISCUSSION

PRESENTED BY

JOHN J. ALEXANDER, Assistant Superintendent Power, Republic Steel Corp., Cleveland, Ohio.

J. A. GOOD, Manager, Electronics Department, Diamond Power Specialty Corp., Lancaster, Ohio.

J. H. STONE, General Foreman, Youngstown Sheet & Tube Co., Youngstown, Ohio.

John J. Alexander: Mr. Good presented an excellent description of an instrument that should find many applications in the production of iron and steel. His paper has dealt with applications of the equipment primarily as a substitute for existing means of communication. I am of the opinion that industrial television will find its greatest application as a method of observing a production process that is inaccessible to other forms of communication.

Would it be possible to operate and maintain a television camera below the large bell of a blast furnace? If installed to withstand pressure, temperatures and abrasive dust condition that exist above the blast furnace stock line, the picture should provide information that would result in improved blast furnace production. Much better distribution of ore, stone, and coke should be obtained if it were possible to observe the material as charged into the blast furnace while in operation. It should be possible to vary charging practice to obtain the desired distribution of material. An improvement in uniformity of the burden should provide more intimate contact of gas and material with a resultant increase in iron production.

My questions are: "Has the camera been developed or protected for use under 40 psi pressure, 500 F temperature and extremely abrasive, high velocity dust conditions; and would it be possible to penetrate dust and gas at the stock line to provide a clear picture?"

J. A. Good: Our only interest is industrial television. It can see anything that you can see with the human eye. In a few cases, it can see some things that you cannot see with the eye. I am referring to infra red-light. We use a filter and that filter tears out all visible light and still the equipment can see it. In fact, the fact that it can see in the infra-red range leads me to believe that it can be used where we have a lot of gases and probably many of the dusts. It has found its use in ability to see through certain fog conditions where the eye cannot see. If the dust and dirt referred to are of the type that will not filter infra-red, and it is difficult to filter infra-red, I think we can see it.

The second question — Will it stand temperature and pressure? The equipment, as it is made, is made to stand temperatures of approximately 150 F. We have not done a great deal with pressure.

We are now constructing a unit for the Army which will meet Class I, Group D specifications. I mean that it has to stand an internal explosion and keep out all the toxic gases which you find in the explosion of equipment. We can place the equipment in a sealed case and use the optic windows which can stand very high temperatures, and I am thinking of a 1000 F or higher, because those windows, being air-cooled and being of pure quartz in nature, can stand those temperatures.

We have already used the equipment to see into furnaces in connection with power plant fields, where we placed a camera in the roof of a furnace, used the water-cooled windows and have watched the burners in the various corners.

The same application has found its way into the oil industry, and it has been suggested to me, in connection with heating furnaces, so I say that the equipment has to be confined to a container, which has to be protected against these high temperatures and pressures.

J. H. Stone: I feel we must give this subject serious consideration due to the ever-increasing costs of our manpower in so far as its practical applications, and in keeping with other technological changes. I am sure that it will be able to justify itself in the original installation and maintenance costs provided that we install it for a good cause.

Television has a number of possibilities from the safety standpoint by removing hazards that one is unable to see due to his position or location in relation to the operation.

One application that comes to my mind is that of its use in soaking pit cranes where the craneman's vision is highly restricted and the work is largely done with mirrors at the present time. Its application in power installations has been worthwhile not only from a manpower savings but from a safety angle as well.

I would like to ask what application if any has been made in regard to inspection of steel surface, pipe, bars, sheets, etc. and how well can the results be read on a television screen.

J. A. Good: If I held my watch up in front of the camera, I could see all the dials. If I held a dollar bill up there, you could not quite see the little cloth hairs in it, but you come awfully close to it. It has been used to read micrometer scales. It has been used to examine cracks in welding over a small area. It all depends upon the distance of the lens from the object televised. The closer we get to the lens, the better. The resulting picture then is magnified and a good example of that was the projection microscope, where you are looking at a small section of area. In our opinion, it can be used for that purpose.

Right now, it is not being used for that purpose. We do not have a single installation, but there are some under consideration, and the one I am thinking of is in connection with a manufacturer of some glass tubes, where this customer would like to show certain people certain parts or phases of the operation, and due to the production set-up no one except a few individuals are permitted in that room. They want to use the camera just to show that particular item without letting the person see any other part of the machine or operation. It can do that job very nicely. We have already proven that.

ILMENITE TESTS SHOW PROMISE

▲ TESTS in which ilmenite was smelted in two electric furnaces, one large and the other small, to produce a titanium-rich slag and marketable pig iron were so successful that further investigation of the process with a view to commercial use is warranted, according to a Bureau of Mines report released by Secretary of the Interior Oscar L. Chapman.

The tests were made in the Bureau's electrometallurgical laboratory at Boulder City, Nev., during July and August 1947, under a cooperative agreement between the Bureau and the Titanium Division of the National Lead Company. About 15 tons of slag containing 65 to 67 per cent titanium dioxide was produced from an ore containing about 30 to 45 per cent, resulting in a material suitable for the production of titanium dioxide pigment in the usual plant facilities. The iron contained in the ore was obtained as pig iron instead of the hard to market ferrous sulfate that would have resulted if the ore had been treated chemically.

The earlier tests in the series were made in a small furnace in which 500 lb of ore were treated at a time. After the small scale batch runs had produced promising results, a larger furnace, that would hold about 2,500 lb of charge normally and about 3,000 lb when tilted backward, was tried.

Besides describing the materials used, the report discusses the theoretical considerations involved in the tests. It describes the 500-lb tests in the small furnace and subsequent production operations in the large furnace. It is illustrated with a graph and several photos.

The report was prepared by C. Kerby Stoddard, formerly Bureau chemical engineer now with the National Lead Co., Sanford S. Cole, assistant research manager, and L. T. Eck, assistant development engineer, Titanium Division, National Lead Co., and the late C. W. Davis, formerly chief of the Boulder City branch of the Bureau's Metallurgical Division.

A free copy of Report of Investigations 4750, "Pilot-Plant Smelting of Ilmenite in the Electric Furnace," can be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes St., Pittsburgh 13, Pa.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Thursday, April 26, 1951 — Dinner 6:00 P.M., Inspection Trip 8:00 P.M.

Combined AISE and ASME INSPECTION TRIP
Coosa River Newsprint Plant
Coosa Pines, Ala.

Inspection Trip — Bus transportation from Birmingham, Ala., 4:00 P.M. Contact Merrill Booth, Crouse-Hinds Co., 514 Watts Building, Birmingham, Ala. Trip starts at 8:00 P.M.

Dinner — Purefoy Hotel, Talladega, Ala.

BUFFALO SECTION

Tuesday, April 10, 1951 — Inspection Trip 4:00 P.M., Dinner 6:30 P.M., Meeting 8:00 P.M.

Inspection Trip — Atlas Steels Ltd., Welland, Ontario, Canada — 4:00 P.M.

"Recent Development on Use of Stainless Steel in the Steel Industry" by John L. Cotsworth, Manager, Stainless Steel Sales, Atlas Steels, Ltd., Welland, Ontario, Canada.

"Rolling and Processing of Stainless Sheets" by Geo. Malcolm, Superintendent of Sheet Mill, Atlas Steels, Ltd., Welland, Ontario, Canada.

Page-Hersey Tubes, Ltd., Welland, Ontario, Canada.

CHICAGO SECTION

Tuesday, April 3, 1951 — Dinner 6:15 P.M., Meeting 7:45 P.M.

Discussion by John Vohr, General Superintendent, Gary Steel Works, United States Steel Co., Gary, Ind.

Phil Smidt's Restaurant, 1205 Calumet Ave., Hammond, Ind.

CLEVELAND SECTION

Cleveland, Monday, April 16, 1951 — Dinner 6:30 P.M., Meeting 8:00 P.M.

Youngstown, Tuesday, April 17, 1951 — Dinner 6:30 P.M., Meeting 8:00 P.M.

Paper by Marc M. Haefele, Eastman Kodak Co., Cleveland, Ohio.

Cleveland: Cleveland Engineering Society, 2136 E. 19th St., Cleveland, Ohio.

Youngstown: El Rio Club, Youngstown-Warren Rd., Route 422, Youngstown, Ohio.

DETROIT SECTION

Tuesday, April 10, 1951 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Maintenance and Care of Steel Mill Bearings" by Steve Kraft, Manager of Maintenance, Steel Operations, Ford Motor Co., Detroit, Mich.

Horace Rackham Educational Memorial, Detroit, Mich.

PHILADELPHIA SECTION

Saturday, April 7, 1951 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"Limiting Maximum Overload on Wound Rotor Induction Motor for No. 4 Mill" by J. W. Deimler, Assistant Supt. Maintenance, Alan Wood Steel Co., Conshohocken, Pa.

"Hydro-Electric Controls for Three-High Mills and Tables" by R. J. Simes, Lubrication Engineer, Lukens Steel Co., Coatesville, Pa.

"Selection and Maintenance of Wire Rope" by G. B. Stoess, Senior Wire Rope Engineer, John A. Roebling's Sons Co., Wire Rope Engineering Division, Trenton, N. J.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, April 9, 1951 — Inspection Trip 2:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Inspection Trip — National Works, National Tube Co., McKeesport, Pa. — 2:00 P.M.

"The 26-In. — 36-In. O.D. Expanded Electric Fusion Welded Pipe Mill" by George C. Anderson, Superintendent Electric Weld Mill, National Works, National Tube Co., McKeesport, Pa.

"Design and Operation of 500-ton Sintering Plant" by E. O. Austermiller, Chief Engineer, National Tube Co., McKeesport, Pa.

University Club, University Place, Pittsburgh, Pa.

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Malvin E. Adams,
Electrician

OZARK HARDWOOD COMPANY

PHONE 252

JOE B. MILLS, MANAGER

CLARKSVILLE, ARKANSAS
April 20, 1950

Bussmann Manufacturing Co.

St. Louis, Missouri

Dear Sir:

I have found a great savings in your Fuzetrons.

Two and one-half years ago I started changing my Dry Kiln motors to Fuzetron protection. Up until I changed completely I was loosing an average of 5 motors per month which was very expensive. I was having to fuze my motors too heavy to pick up the load, then if something went wrong the fuze were too heavy and held the motor on the line, therefore burning it up.

My Kiln motors are 1½ h.p. 5 amp. I fuze them with 5 amp fuzetron. The fuzetron will hold this starting load and when it picks up I still have motor protection if anything goes wrong the fuzetron will blow in time to keep the motor from burning up. I fuze my main pannell with 6 - 600 amp. fuzetron. I used to blow fuzes on this until I changed to fuzetron, therefore, taking care of the surging load.

I have approximately 800 h.p. I fuze almost all the plant on fuzetron. My trouble has been very light since changing to fuzetron for motor protection Fuzetron is tops with me.

Yours very truly,

Malvin E. Adams

Malvin E. Adams
Electrician

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Give 10 Point Protection

1. ★Protect against short circuits.
2. Protect against needless blows caused by harmless overloads.
3. Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. Protect motors against burnout from overloading.
6. Protect motors against burnout due to single phasing.
7. Give DOUBLE burnout protection to large motors — without extra cost.
8. Make protection of small motors simple and inexpensive.
9. Protect against waste of space and money — permit use of proper size switches and panels.
10. Protect coils, transformers and solenoids against burnout.

★ Fusetron Fuses have high interrupting capacity as shown by tests of the Electrical Testing Laboratories of New York City in December 1947.

What is the FUSETRON Dual-Element FUSE?

A fuse link combined with a thermal cut-out — the result, a fuse with tremendous time-lag and much less electrical resistance.

They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to same dimensions as ordinary fuses, FUSETRON Fuses fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

Don't risk losses in your plant!

One **lost** motor,
One **needless** shutdown,
One **destroyed** panel or switch,
One **burned out** solenoid —
May cost you more than replacing every ordinary fuse with a FUSETRON dual-element fuse.

Fusetron is a trade mark of Bussmann Mfg. Co., Division of McGraw Electric Co.

Bussmann Mfg. Co., University at Jefferson, St. Louis 7, Mo. (Division McGraw Electric Co.)

Please send me complete facts about FUSETRON Dual-Element FUSES.

*Name*_____

*Title*_____

*Company*_____

*Address*_____

*City*_____ *State*_____ 351

NATIONAL TUBE COMPANY COMPLETES NEW BOILER PLANT *at McKeesport*

▲ Smokeless stacks on the new boiler plant of National Tube Co.'s National works, McKeesport, Pa., are not a sign of slack business, but of the cooperation of industry with the smoke control program of this busy steelmaking center. Designed to produce an absolute minimum of fume and solids in waste gases, the new boilers are fired with gas from this U. S. Steel plant's four blast furnaces, with pulverized coal as an auxiliary fuel.

An average of 17,400,000 cfhr is produced by the four blast furnaces. Of this amount, approximately 69 per cent, or 12,000,000 cu ft is available for use in the new boiler house.

Gas cleaning is accomplished in two modern gas washers and two electrostatic precipitators. A main 9 ft in diameter conducts the gas from the furnaces to the washers. Based on a capacity of 230,000 cfm of gas the washers reduce the dust content to 0.25 gr per cu ft by passing the gas through multiple fine sprays of water.

From the washers the gas passes to two double-compartment precipitators. Here it flows through a high-tension electrical field, becoming part of the electrical circuit, with the result that the solids are precipitated through the action of electrostatic charges. The precipitators reduce the dust content of the gas to 0.01 gr per cu ft.

The dust in the precipitators is washed away constantly and flows by gravity to a 90-ft diameter multiple-trough thickener. The sludge effluent from the wet washers is pumped to this same thickener.

The settled solids from the thickener are pumped directly to a drum-type vacuum filter which can produce 172 tons of filter cake in 24 hours. This cake, with a moisture content of 25 per cent, is scraped from the drum and dropped directly into cars for removal to the ore stock pile for recovery by sintering.

Coal for the new unit is handled in the conventional manner. First lifted from barges by a coal tower, it passes through a crusher to a storage hopper, then is fed by means of seven rotary-vane feeders, with a capacity of 150 tons an hour, to a belt conveyor for discharge into a bucket elevator.

From the elevator the coal discharges to a belt conveyor equipped with a tripper and mounted over the boiler house coal bunkers. Removal of tramp iron is accomplished by two magnetic pulleys on the conveyors.

From the boiler house bunkers, the coal passes down through spouts to automatic scales, thence to the feeders and on to the pulverizers. Each boiler is equipped with its own scale, feeder, and pulverizer.

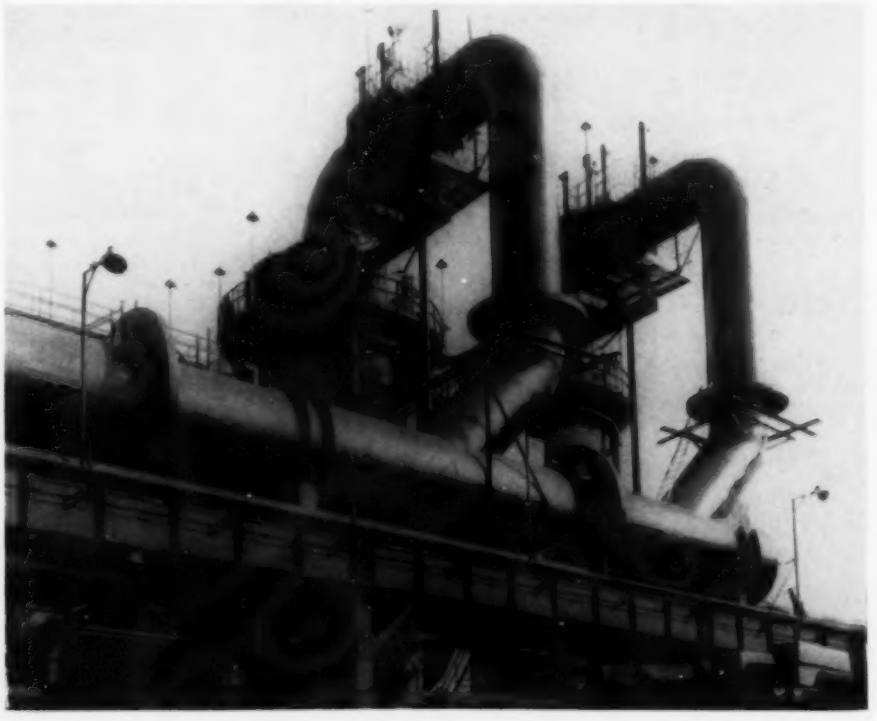
Gases and fly ash emanating from coal are controlled by dust collectors designed to meet the requirements of the new Allegheny County (Pittsburgh and environs) Smoke Control Ordinance. The ash-handling system is of the conventional vacuum type with a capacity of 20 tons an hour. It collects from ash hoppers, boiler soot hoppers, dust collector hoppers, and stack hoppers, and delivers into a 100-ton capacity silo through a cyclone and air washer. Ashes from the silo are discharged into either trucks or cars by a dustless unloader.

There are five, two-drum boilers with fully water-cooled furnaces in the new unit. When burning gas, the steam output of each boiler of the plant will be 175,000 lb an hr. With output of steam from coal limited to the use of a single pulverizer for each boiler, the capacity will be 125,000 lb an hr.

Each boiler is furnished with a 60-in. diam upper drum and a 42-in. diam lower drum providing a heating surface of 13,800 sq ft. The water-cooled furnace tubes add an additional 4407 sq ft of heating surface. Furnace volume is 14,300 cu ft.

Because of availability and past satisfactory performance, tangentially fired units were selected. The boilers are equipped with two-section tubular-type air preheaters with a total

Figure 1 — Smokeless smoke stacks are evidence of efforts toward smoke control at the National works of U. S. Steel's National Tube Co. at McKeesport, Pa. A major step toward smoke control is the installation of two modern gas washers and a companion set-up of electrostatic precipitators for cleaning gas from the furnaces, for use in the mill's new high-pressure boiler plant. A second anti-smoke development at the plant, one of the nation's largest producers of steel pipe, is the installation of dust collectors that virtually eliminate the fly ash coming from the boiler stacks when coal is used for fuel instead of the blast furnace gas.



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The makers of Hardtem—first prehardened die block for drop hammer forgings—now introduce *"Prestem"*, a new steel analysis developed especially for the hot working of steels in forging presses and upsetters.

Prestem is available in the form of blocks and bars for solid press dies, insert dies, upsetter dies, and punches. It machines readily at high hardness . . . has high impact resistance . . . can be water cooled during forging operations.

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The same steel can be obtained in the annealed condition and is distributed under the trade name *Presneal*. Write for the *Prestem* folder or call your Heppenstall representative for more information. Heppenstall Company, Pittsburgh 1, Pa. Sales offices in principal cities.

Heppenstall —*the most dependable name in die blocks*

heating surface of 16,500 sq ft to provide an over-all efficiency, at full load of 75 per cent with blast furnace gas and 84 per cent with coal.

Coke oven gas pilot burners are installed in each unit and are capable of producing about 20,000 lb of steam an hour at full valve opening. Superheat temperature from each boiler is controlled by an automatically operated atomizing, spray-type desuperheater in each boiler steam discharge outlet. There are no surface condensers available to provide pure water for this purpose, so the condensate from the high and low-pressure heaters is used.

While only five boiler units are installed, space is provided in the 7-story building for a sixth unit at some future date.

To minimize maintenance and operational problems, all driven units possible are located on the ground floor. All feed water heaters and pumps are concentrated in one bay at the east end of the boiler house.

Most auxiliary units having high power requirements are steam turbine driven with electrically driven standby units for flexibility of operation and protection against failure. Pressure for driving the auxiliary turbines were determined from heat balance studies.

Pulverizer drives are an exception, for it was felt that steam requirements from coal are so low (approximately 10 per cent of the total) that only a drastic failure of all five units could affect plant operation. As a result, all pulverizers, feeders, and scales are motor driven.

With the exception of the coal-handling system, from coal tower to pulverizers, all units are broken up into duplicate sizes and are so cross-connected that only a major failure can seriously affect plant production. Pumps are also installed in duplicate sizes of partial plant capacity, with an extra unit as emergency standby.

Clean water for the boilers presented a problem, as no condensate return can be anticipated in the immediate future, leaving raw river water from the Monongahela River as the only available source. To solve the problem, it was decided to make use of seven existing settling basins and to hasten the settling process by the use of coagulants.

The new water softening plant is of conventional design except for size as related to steam output. Because of the varying qualities of the make-up water and consequent varying blowdown from the boilers, it was necessary to design the water-softening plant larger than is customary.

The treating plant is of the lime-soda, hot-process type, effecting silica and hardness reduction in reaction tanks, followed by filtering and stabilization before delivery to de-aerating equipment.

There are three softening tanks operating at 25 psi pressure and with a maximum capacity of 1,875,000 lb an hr, based on 90-minute retention time. Normally, only two will be in use as softeners and the third will be used as a softened water storage tank.

Fourteen pressure type filters are installed immediately west of the water softening building. Three lime-soda mixing tanks and pumps, two sulphite mixing tanks and pumps, two phosphate mixing tanks and pumps, and one acid tank and pumps constitute the auxiliaries. Each boiler is furnished with its own phosphate feed pump, arranged for timed phosphate feed and automatic flushing of the lines, however.

All chemicals are handled from cars by means of skids and a storage-battery lift truck, up an elevator and down a ramp to the second floor of the water-softening plant. Bags of chemicals are opened on this second floor and the contents poured through a pipe to the proper mixing tanks. The mixing tanks are served by a separate ventilating system discharging into a small cyclone collector from which waste materials can be recovered.

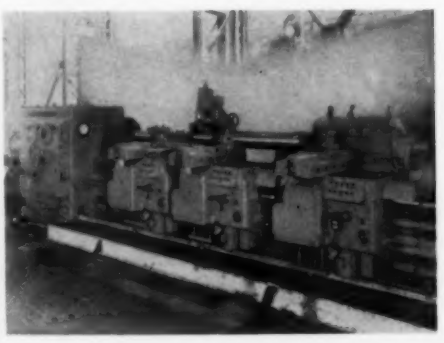
Indicating and recording instruments and control stations throughout the plant keep the staff thoroughly informed and in control of operating conditions at all times, while up-to-date safety factors and building services make the new smokeless, high-pressure boiler plant a safe and comfortable place for employees.

TWO NEW LATHES

Reflect Machining Advances

▲ Two new lathes, both using tungsten carbide-tipped work tools, were announced recently by the Heppenstall Co. One of these is a revolutionary high speed trepanning lathe which was demonstrated by the company in its Pittsburgh plant to a group of steel mill and machine tool men. The other, a rough turning lathe, is still under development although the company expects to have at least two built. Of the two, the rough turning lathe will be of greater interest to the steel industry, as it is expected that one lathe will be able to do the work of two ordinary units. Advantages are high rates of metal removal with automatic removal of chips, quick methods of changing tools, a simple design for contour machining with complete instrument indication. The lathe also uses three carriages each of which is relatively short in length, and there is full control of the lathe from each carriage.

Figure 1 — The German rough turning lathe.



These two lathes were originally

developed in Germany. Some of these units were moved to England after the war where much work has been done on their operation. Russia also obtained a number of these units. It is claimed that the rough turning lathe will remove metal at rates up to 2000 lb per hr and the unit can handle pieces up to 30 ft long, 30 in. in diameter and 25 tons in weight. Longitudinal feed varies from 0.016 to 0.160 in. per revolution in three overlapping ranges which make up this total range. A rate of traverse of 120 in. per minute is provided and the work can be driven at 9.2 to 275 rpm. Maximum torque at low speed is 265,000 in. lb. The unit is driven by a 125/150 hp d-c motor, through change gears at 9.2-275 rpm.

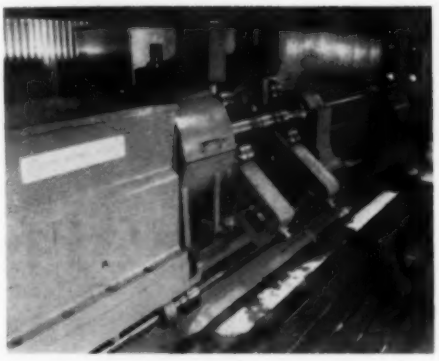


Figure 2 — Heppenstall trepanning lathe at the Pittsburgh Plant.

The trepanning lathe is very unusual and many unusual engineering details have been developed by the Heppenstall Co. over the original design. These developments include such features as variable voltage main drive, gearless head stock, infinitely variable hydraulic feed and complete instrumentation which gives indications of:

1. Per cent load on main motor drive.
2. Rate of feed on inches per minute.
3. Surface speed of cutting tool at point of cutting and rpm of main spindle drive.
4. Coolant pressure and temperature.

The trepanning lathe has the inherent advantages in that the cuts take out a core thus eliminating the work required to reduce the complete bore to chips. In addition, it may be possible to use the core for other operations thus saving scrap material. Production of the lathe is about twenty times that of an ordinary unit. An actual case record is given in Table I.

TABLE I

Performance Record Covering Trepanning on 8 In. Outside Diameter x 2⅝ In. Inside Diameter x 48½ In. Long Round

Speed	900 rpm
Feed	0.010 per rev.
Load before cut	14 hp
Load when cutting	42/49 hp
Oil pressure	200 psi
Oil temperature at start	50 F
Oil temperature at finish	55 F
Temperature rise	5 F
Actual length trepanned	45½ in.
Actual time	5 min 16 sec
Diameter of bore, entrance end	2.628 in.
Diameter of bore, exit end	2.630 in.
Diameter of core	1.126 in.
Eccentricity	0.002 in.
Rate of penetration	540 in. per hr

Grade of Steel Similar to AISI — 4340 Modified

Carbon	0.41 per cent
Silicon	0.28
Manganese	0.74
Nickel	1.72
Chrome	0.87
Molybdenum	0.45
Brinell Hardness	311

Observations

The surface of the hole was bright and smooth.
The chips were small and constant from start to finish.
American tungsten-carbide tool and guide pieces were used. The tool and guide pieces were in good condition.
The performance of lathe and steady rests was good.

As indicated by Table I production rates are high. Penetration rates up to 540 in. per hr have been achieved on specimens of the same size as the one reported in the test given in Table I. Generally no further boring or machining is necessary.

The lathe used at the Pittsburgh test demonstration is driven by a 75 hp 400/1600 rpm d-c motor. Speeds from 20 to 900 rpm are obtained through change gears. A maximum torque of 53,000 in. lb is obtained at low speeds at the spindle. The trepanning tool feed can be varied from 0.002 to 0.600 in. per revolution at spindle speeds of 20 to 600 rpm and from 0.0015 to 0.400 in. per revolution, at spindle speeds from 600 to 900 rpm. The lathe can trepann holes from 1¾ to 15 in. in diameter and the trepanning head carries but one tool in contrast to the multi-tool heads used in the U. S. An auxiliary motor

Figure 3 — A control panel with only a few push buttons is one of the features in the operation of the new high-speed trepanning lathe. On the wall in front of the operator are instruments that record lathe revolutions per minute, rate of feed in inches per minute, per cent load on main motor drive, plus coolant temperature and pressure.

drive is used to withdraw the trepanning tube which operates at speeds up to 100 in. per minute.

This lathe should be particularly useful for boring gun barrels, gear forgings, drill collars, and rotor forgings. The unit demonstrated is only an example of what may be built and much larger units can be designed on the same principle. The Heppenstall Co. is licensed by Schiess, A. G. Dusseldorf, Germany. It does not intend to manufacture the units, but is interested in leasing the design to machine tool manufacturers. At the present time, however, they will accept orders for redesigning and rebuilding through sub-contractors any suitable American boring lathes.

PLAN TO ATTEND!

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Lower photo: **F. E. I. installation for galvanizing metalware.**

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Date-line Diary...

February 1

▲ Jones & Laughlin Steel Corp. reports net earnings of $39,744,000 for the year 1950 on revenues of $487,451,000 or $7.36 a share after dividends on preferred stock. This compares with earnings of $22,248,000 for 1949.

▲ Youngstown Sheet & Tube Co. reported net income for 1950 of $40,616,403, compared with $31,777,010 for 1949. Total revenues for 1949 were $409,898,732.

February 2

▲ American Iron and Steel Institute reports that pig iron production in 1950 hit a new record and final figures, exclusive of ferro-alloys, totaled 64,589,140 net tons. A total of 5,692,000 tons were sold to users outside of the steel industry.

▲ The Bureau of Statistics of the Canadian government reported ingot production in 1950 hit a new record of 3,298,069 tons.

▲ Department of Commerce reports that manufacturers sales in 1950 totaled $235,000,000,000.

February 3

▲ Colorado Fuel and Iron Corp. has contracted to buy the capital stock of Worth Steel Co. which operates a plant at Claymont, Del., thus extending its operations to the Atlantic Seaboard.

February 4

▲ The Koppers Co. reports net income for 1950 of $11,615,498 after taxes.

February 5

▲ Based on AISI reports from companies having 93 per cent of the capacity of the industry, the operating rate for the week beginning February 5 is estimated at 96.7 per cent of capacity. This is equivalent to 1,933,100 tons of steel compared with 2,025,000 one week ago.

▲ United States Steel Corp. awarded construction contracts for the mill at Morrisville, Pa. to Walsh Construction Co. and their associates Louis R. Perini Construction Co., S. J. Groves Co., and Slattery Construction Co.

▲ Granite City Steel Co. purchased the pig iron and coke plant formerly operated by Koppers Co. in Granite City, Ill.

February 6

▲ Granite City Steel Co. reports preliminary 1950 figures give a net profit of $5,727,405 or $11.52 a share after charges.

▲ Inland Steel Co. is planning to open a new iron ore mine with an eventual annual production capacity of 200,000 tons near Crystal Falls, Mich.

▲ American Iron and Steel Institute reports that steel and iron producers estimates for expansion and improvement during 1951 will be $1,200,000,000.

▲ Vanadium Corp. announced that it plans to build a plant for the production of silicon alloys near New Haven, W. Va. at an estimated cost of $7,000,000.

February 7

▲ The aluminum industry produced a total of 1,437,255,518 lb of aluminum in 1950 or 19 per cent more than any previous year. Shipments of sheet and plate totaled 1,155,318,982 lb. Present plans should increase capacity about 20 per cent in 1951.

▲ International Nickel Co. reports that delivery of nickel in all forms were 256,000,000 lb, a record for any peace-time year.

February 8

▲ The Maritime Administration placed orders for 25 fast freighters at a cost of $200,000,000.

▲ National Steel Corp. reported net earnings in 1950 of $57,814,974 or $7.85 a share compared with $39,311,269 in 1949.

▲ Acme Steel Co. declared its 287th consecutive dividend since 1901 with a payment of 50¢ a share to stockholders of record on February 20.

February 9

▲ An NPA official stated that automobile model changes may be stopped after next fall.

▲ Chas. E. Wilson, Defense Mobilization Chief, stated that defense spending for materials alone will be about $55,000,000,000 between now and January 30, 1952.

▲ American Railway Car Institute reported that orders of 26,356 new cars were placed in January. Deliveries totaled 5949 leaving a backlog as of February 1 of 144,758, the highest in history.

February 10

▲ Tin prices at Singapore rose to $1.8117 a lb or at a price, taking freight into account, higher than U. S. ceilings.

▲ A new company, Tidewater Industries, Inc., is planning to build a steel plant in the James River area east of Richmond, Va. Proposed capacity is about 1,000,000 tons annually.

February 12

▲ The F. W. Dodge Corp. reported that construction awards for the thirty-seven states east of the Rockies in January totaled $1,043,248,000, 10 per cent down from December and 43 per cent ahead of a year ago.

▲ The AISI reports that the operating rate of the steel industry for the week beginning February 12 is scheduled at 98.5 per cent. This is equivalent to 1,969,000 tons of ingots and castings compared with 1,933,100 tons one week ago.

February 13

▲ Department of Commerce reports that consumer incomes in December were at an annual rate of $240,700,000,000.

February 14

▲ Economic Stabilizer Johnston states that price-wage control violations will be prosecuted by 96 special U. S. attorneys.

February 15

▲ Stockholders of ALCOA authorized an increase in indebtedness from $200,000,000 to $500,000,000. This is one step in financing the expansion program.
▲ North American Steel Co. is considering construction of a large steel plant at Camanche, Iowa. Estimated capacity will be 400,000 tons pig iron and 1,000,000 tons of finished steel.
▲ U. S. Steel Co. awarded contracts to Koppers and Allied Chemical for construction of open hearths and coke oven batteries at its proposed plant in Morrisville, Pa.
▲ Woodward Iron Co. announced a $4,000,000 expansion program in which the major item consists of 30 additional coke ovens.
▲ Green River Steel Corp. received a government loan of $8,356,000 for construction of an electric furnace at Owensboro, Ky.

February 16

▲ Government directed steel producers to reserve increased amounts of steel products for defense. Increases range from 2 to 25 per cent.
▲ The AISI reports steel production in January set a new high of 8,830,000 tons.
▲ A new wage formula approved by the Wage Stabilization Board will allow many workers wage boosts up to 10 per cent above level of January 15th.
▲ NPA placed controls on lead and antimony for the first time.

February 18

▲ Mackintosh-Hemphill plans an expansion program at the Midland, Pa. plant.

February 19

▲ The AISI reports that the operating rate of the steel industry for the week beginning February 19 will be 99.5 per cent of capacity. This is equivalent to 1,989,000 tons of ingots and castings compared with 1,969,000 tons one week ago.

February 20

▲ E. I. du Pont de Nemours reported record earnings in 1950 of $6.59 a share compared with $4.52 in 1949.
▲ Granite City Steel Co. has borrowed $12,250,000 from eight banks and plans to raise $6,000,000 through sale of additional common stock.

February 21

▲ The NPA announced it will issue orders to cut steel use by automobile, refrigerator, and other consumer goods manufacturers about 20 per cent.
▲ The Yolo Steel and Metal Co. is planning a $264,000,000 steel plant in central California with a 1,000,000 ton per year capacity.
▲ The Seidelhuber Steel Rolling Mill Corp. has been formed to construct a strip mill in the Seattle area.

February 22

▲ Bethlehem Steel Co. granted 18½¢ to 23¢ an hr wage increase to their shipyard workers in the east retroactive to January 1.
▲ Crucible Steel Co. consolidated net income for 1950 was $6,311,254 or $9.73 a share after preferred dividends. This compares with $1,352,000 in 1949.

February 23

▲ R. W. Wolcott estimates that there will be a deficit of 5,000,000 to 7,000,000 tons of iron and steel scrap by the end of 1952.

February 25

▲ The AISC reports January bookings of fabricated structural steel of 285,087 tons. Shipments for January were 171,886 tons leaving a backlog of 2,136,865 tons.
▲ The Ohio Ferro-Alloys Corp. is planning a new plant for the production of ferro-alloys at Brilliant, Ohio.
▲ Donner-Hanna Coke Corp. plans to spend $2,300,000 for expansion and modernization of its Buffalo plant.

February 26

▲ AISI reports that the operating rate of the steel industry for the week beginning February 26 will be 99.8 per cent of capacity. This is equivalent to 1,995,000 tons of steel ingots and castings compared with 1,989,000 one week ago.

February 27

▲ Pittsburgh Steel Co. declared a dividend of $25.62½ on its class A 5 per cent preferred stock thus clearing all arrears.
▲ E. G. Grace, chairman, Bethlehem Steel Corp., announced that his company's capacity will reach 17,600,000 tons by the end of 1952.
▲ The NPA cutback allotments to rail equipment makers to allow construction of only 9000 new freight cars. This was cut back to better reflect the pace of the car building program.

February 28

▲ Westinghouse Electric Corp. reported net income for 1950 of $77,922,944, which after payment of dividends on preferred stock was equivalent to $5.36 a share. Net sales for 1950 totaled $1,019,923,051, a new record.
▲ The Republic Steel Corp. announced that it will begin construction at its South Chicago Works of a new seamless tube mill.
▲ The AISI reports wages and payroll for 1950 set a new record of over $2,300,000,000. Payments average $1.73 an hr for an average 40 hr week. Total employment was about 653,000.
▲ Bethlehem Pacific Coast Steel Corp. announced that it is installing an additional furnace at its Los Angeles plant.
▲ The House Agriculture Committee predicted that sulphur demand in 1951 including exports will exceed supplies by 800,000 tons.
▲ Allegheny Ludlum Steel Corp. announced sales in 1950 of $177,961,693, net earnings of $9,814,891 or $7.07 a share. This compares with net earnings of $1,967,324 in 1949.

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YOUNGSTOWN SHEET & TUBE CO. — Youngstown, Ohio — 1915
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McKINNEY STEEL CO. — Cleveland, Ohio — 1924
McKINNEY STEEL CO. — Cleveland, Ohio — 1926
FORD MOTOR COMPANY**** — River Rouge, Mich. — 1928
YOUNGSTOWN SHEET & TUBE CO.* — Indiana Harbor, Ind. — 1928
YOUNGSTOWN SHEET & TUBE CO. — Indiana Harbor, Ind. — 1929
INTERSTATE IRON & STEEL CO.* — Chicago, Ill. — 1929
WHITEHEAD IRON & STEEL CO. — Newport, England — 1930
ILLINOIS STEEL COMPANY*** — Chicago, Ill. — 1930
JONES & LAUGHLIN STEEL CO. — Pittsburgh, Pa. — 1932
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SHEFFIELD STEEL CO. — Kansas City, Mo. — 1947
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SHEFFIELD STEEL CORP. — Houston, Tex. — 1948
DOMNARFVETS JERNVERK**** — Domnarvet, Sweden — 1948
LANCASHIRE STEEL CORP.* — Warrington, England — 1949
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Industry News...

REPUBLIC STEEL CORP. TO CONSTRUCT SEAMLESS TUBE MILL AT SOUTH CHICAGO

▲ Plans for the construction of a seamless tube mill at the South Chicago, Ill., works of Republic Steel Corp. have been announced. The mill will be the first facility for the production of tubular products by Republic Steel in the Chicago district.

Work on the project will begin immediately and the first production is expected by April, 1952.

A certificate of necessity has been granted by the government allowing a major part of the cost of the tube mill as a defense facility to be amortized for federal income tax purposes over a five-year period.

The mill will enable Republic to produce in excess of 150,000 tons of seamless tubular products per year. Sizes from 2⅜ in. OD up to 9⅝ in. OD will be produced.

Some of the production of the mill will go into oil country casing and tubing for oil wells 10,000 ft and deeper, pipe for high temperature, high pressure service and refinery still tubes. These require tubing with heavy walls made from special analysis steels. With an increasing demand for such materials and construction of the seamless tube mill will round out Republic's facilities for manufacturing a complete line of steel tubular products.

The company currently produces electric fusion welded line pipe in diameters up to 30 in. OD, and electric resistance welded line pipe in diameters up to 16 in OD and oil country casing up to 13⅜ in OD. Moreover, a large proportion of the alloy steel production of the company goes into drilling tools and other equipment for the oil and gas industries. Thus, construction of the seamless tube mill will permit Republic to serve these essential industries even better than before.

In addition to its many uses in these industries, seamless tubing is also essential in the manufacture of many types of ordnance and for other defense purposes.

The South Chicago plant is an integrated steel plant consisting of by-product coke ovens, sinter plant, a blast furnace, four open hearth and nine electric furnaces, blooming, billet, bar and rod mills, spike factory and wire, nail and wire products plant. In the past, operations have centered about the production of carbon and alloy steel blooms, billets, bars and rods, carbon and alloy plain and galvanized wire, spring wire, barbed wire, woven wire fence, bale ties, nails and staples. The seamless tube mill will provide better product diversification for the plant.

The seamless mill will be erected in existing buildings adjacent to the finishing facilities of the 44 in., 36 in., 32 in. mills on which the tube rounds will be rolled. The finishing and shipping departments will be set up in buildings elsewhere in the plant. Additional steel ingot capacity is being secured by enlarging existing furnaces.

The first step in the production of seamless tubing is the reheating of the billets or "tube rounds" for piercing. This will require construction of a reheating furnace operating on mixed natural gas, coke oven gas or oil.

The tube rounds will be pierced on typical Mannesmann or parallel axis barrel-type piercing mills. These mills are the most widely used piercing mills in the industry. They permit a variation in piercing speeds which is essential since certain alloy steels must be pierced at lower speeds than ordinary carbon steels.

COMMUNICATION CENTER SPEEDS MESSAGES

Harvey B. Jordan (left), president of American Steel & Wire Co., inaugurates the new high-speed communications center in Cleveland, Ohio, by pressing the button which transmits the first message to the 148 other stations on the U. S. Steel leased wire network. Also present for the occasion were, from left to right, Winnifred E. Martin, staff assistant-communications, U. S. Steel Co.; Roger W. Baridon, supervisor of communications, U. S. Steel Co.; and T. E. Manning, director of leased wire services, Western Union Telegraph Co. Below Mr. Jordan's hand is shown the "automatic finger" which turned on the equipment by means of an electrical impulse obtained from one of the blast furnaces of American Steel and Wire in Cleveland where the molten metal fused a wire and activated a relay.

After the piercing operation the tubing will be reheated and transferred to a plug mill. This mill reduces the wall thickness of the tube by rolling the tube over a stationary round plug. The tube is then transferred to a reeling machine which irons out wall variations and at the same time produces a smooth inside and outside finish. Due to the longer length of tube going through the reeler and the necessary slower feed, two reeling machines will be required to keep up production with the piercing mills and the plug mill. The tubes will be alternately fed through the two reelers.

A special type of machine known as an Assel mill will also be installed. This will provide for high precision in the wall reduction of certain specialized types of tubing, particularly those to be used for bearing stock.

The final steps in the production of the tube will be undertaken on reducing and sizing mills. These operations are required to produce tubing with the tolerances demanded by industry. Finishing and shipping equipment will also be installed.

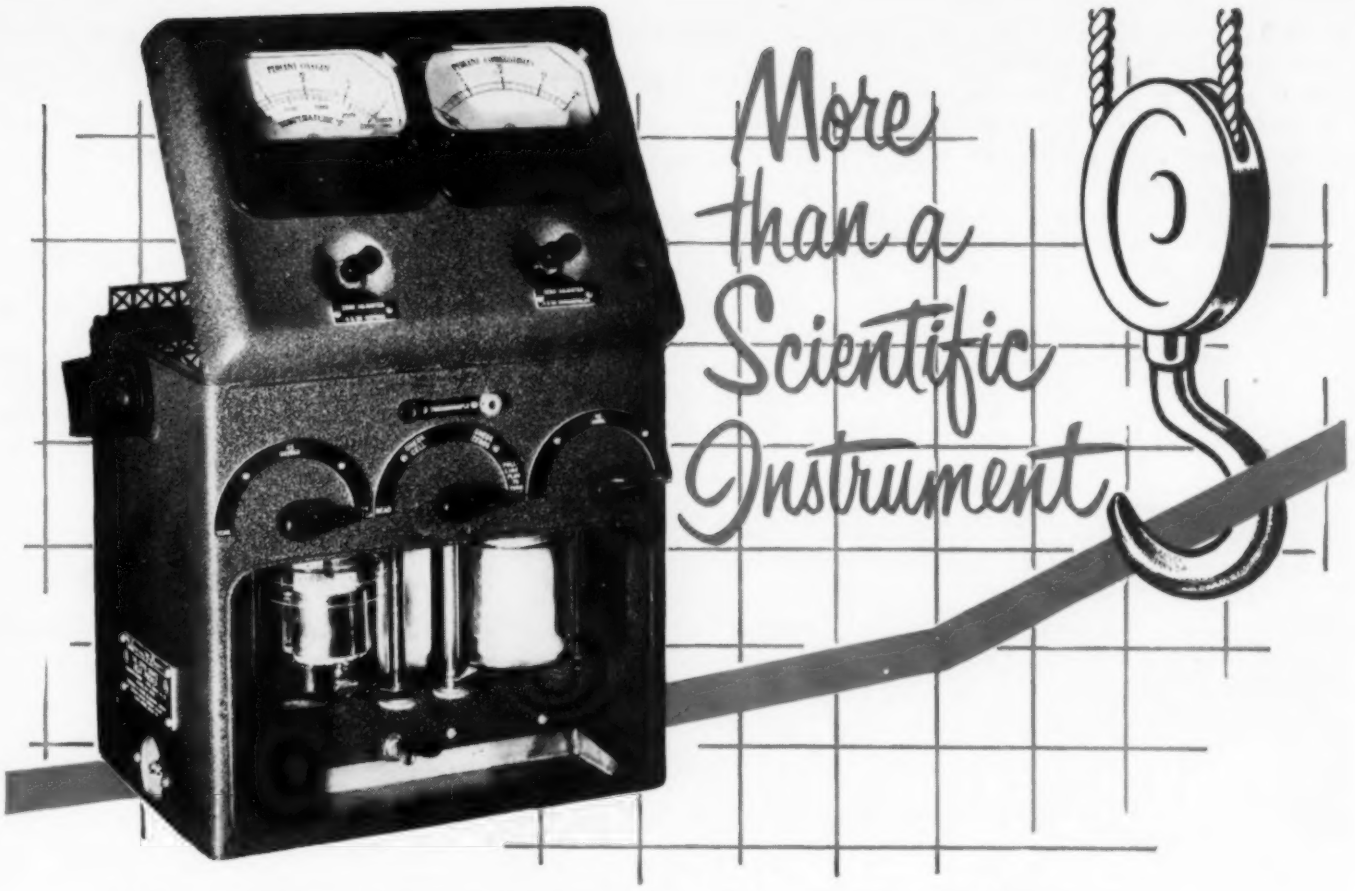
CLARK CONTROLLER ADDS TO MANUFACTURING AREA

▲ Clark Controller Co. has approximately doubled its manufacturing space by the acquisition of two buildings adjacent to its present property and by a rental of 50,000 sq ft in the building at 30th and Chester in Cleveland, Ohio. This expansion has included the purchase of a building at 1170 East 152nd St., now occupied by Reliance Electric and Engineering Co. and the building north of their property now occupied by Ohio Bronze Powder Co. These two purchases provide an additional 75,000 sq ft. In addition they have an option to acquire, through lease, another 50,000 sq ft in the building at 30th and Chester.

INTERNATIONAL NICKEL SEES RECORD SHIPMENTS

▲ Deliveries of nickel in all forms in 1950 by International Nickel Co. of Canada, Ltd., were 256,000,000 lb. Deliveries in 1949 were 209,292,257 lb.

The company's receipts from sales of nickel, copper, platinum and other



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products for 1950 amounted to $228,000,000 (in terms of U. S. currency) which compared with $182,806,452 for 1949. The company's current production of nickel is at maximum capacity and is expected to be larger in 1951 than in any year in its history.

Barring unforeseen interruptions, the company will complete in 1953 its program of full conversion from surface to underground mining which has absorbed the major portion of its $100,000,000 in capital expenditures over the past ten years.

ALLIS-CHALMERS BUYS CANADIAN ASSETS

▲ The purchase of all the physical assets of Canadian Allis-Chalmers, Ltd., by a new wholly owned subsidiary of Allis-Chalmers Manufacturing Co. of Milwaukee, Wis., was announced by the parent concern.

The new subsidiary is known as Canadian Allis-Chalmers (1951), Ltd.

The Canadian firm, which employs approximately 525 people, will continue the production of heavy machinery for the Canadian market. M. C. Lowe, formerly vice president of Canadian Allis-Chalmers, Ltd., has been named president of the new Allis-Chalmers subsidiary.

STRESS ANALYSIS GROUP TO MEET MAY 16-18

▲ The 1951 Spring Meeting of the Society for Experimental Stress Analysis will be held at the National Bureau of Standards and the Wardman Park Hotel, Washington. D. C., on May 16, 17 and 18.

ACCIDENT ENDS LONG PLANT SAFETY RECORD

▲Surpassing the previous safety record for the entire American steel industry by well over a million manhours, Ellwood works of U. S. Steel's National Tube Co. at Ellwood City, Pa., finally ended their string of 385 accident-free days on February 20 when an employe was treated for a foot injury.

Since the last lost-time accident at the plant, the 3,300 employes had amassed a total of 6,743,644 manhours of safe work, dating back to January 29, 1950. The previous best safety record in the nation's steel industry was 5,598,367 manhours without a lost-time mishap.

It is a coincidence that the last lost-time accident at this plant previously resulted in an employe suffering a broken toe from a falling piece of steel.

In the latest accident, a steel piercing plug struck the employe's extended foot at an angle so that the sharp end of the plug went behind the safety toe guard on the man's shoe, resulting in the injury.

CONTRACTS LET FOR COKE AND OPEN HEARTH PLANTS

▲ United States Steel Co. has announced the award of a contract to the Wilputte Coke Oven division, Allied Chemical and Dye Corp., for designing, furnishing and erecting two coke oven batteries of 87 ovens each at the new Fairless works, Morrisville, Pa. The new ovens will be Wilputte underjet, four-divided, low-differential coke ovens with a com-

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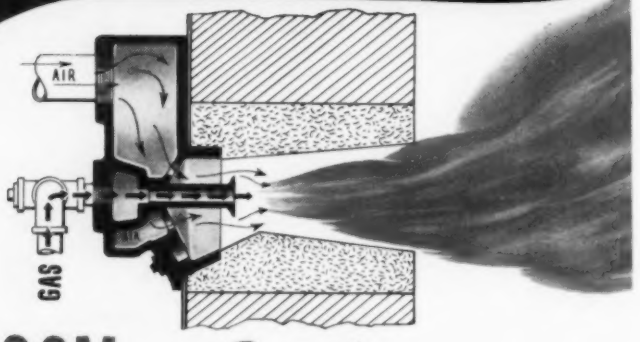

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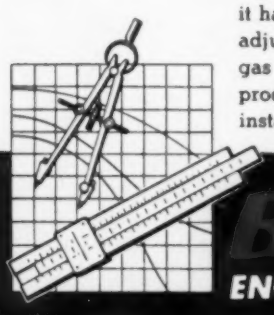
Due to the luminous, high heat-radiating flame produced by the Bloom LONG FLAME Burner, exceptionally uniform temperatures can be maintained throughout the furnace chamber. By eliminating hot spots and cold spots, you get high quality work, improved furnace production and greatest economy.

This burner permits maximum flexibility in furnace operation, for it functions efficiently at temperatures from 400° F. to 2450° F. It will light at full capacity and burn as long as it has fuel. Available in various capacities, adjustable and non-adjustable types, for oil, gas and oil or gas. For maximum furnace production and minimum fuel consumption, install Bloom LONG FLAME Burners.



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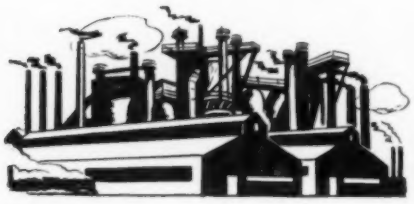
The steel industry needed the world's largest ram trucks...



Today huge coils of steel are rolling off continuous wide strip mills at a mile-a-minute clip. Naturally these wider, longer coils mean better, less costly steel, and more of it. And as a result coil sizes have grown—until today it takes the world's largest ram trucks to handle the output.

...so YALE built them!

These rugged, hard-working giants, now available in capacities ranging from 10 to *50 tons*, well illustrate YALE's unique ability to meet the rigid demands of the steel industry. These powerful trucks, equipped with front wheel drive, fully articulated wheels, fingertip steering control and all welded steel construction, can easily keep pace with a tremendous volume of steel production.

Let YALE solve your toughest handling problems!

YOU CAN keep materials moving, keep your handling equipment on the job, *keep production at a constant high level* when you've got YALE trucks working for you. Here are trucks engineered by YALE, in close collaboration with steel industry engineers to outwork and outwear any truck on the market! Let us show you *how much more* YALE equipment can do for you. Send coupon today!

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bined capacity to produce annually 916,000 net tons of coke and, in addition, large quantities of gas and valuable chemicals.

The facilities contracted for will be complete with coal and coke handling equipment and by-product recovery facilities. The ovens will be equipped with Wilputte special design self-sealing hydraulically-operated doors, and with flexible steel sealing plates and renewable stainless steel sealing strips. By installing suitable auxiliary equipment at some future time, the ovens can be underfired with blast furnace gas which will be generated at the two large blast furnaces to be erected at the Fairless works.

Koppers Co., Inc., was given a contract for the engineering and construction of the open hearth furnaces. Koppers' Freyn department, with offices in Chicago, Ill., will engineer and construct the nine 275-net-ton open hearth furnaces to be built at this works.

AUSTRIAN FIRM BUYS LEWIS BLOOMING MILL

▲ Lewis Foundry & Machine division of Blaw-Knox Co. has received an order from Austria under ECA provisions for a two-high reversing blooming mill, including manipulators, tables and other accessories.

The award was placed by the Alpine Montan Co., largest steel producer in that country, and is for installation at the Donawitz Steel Works.

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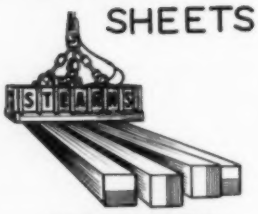

BILLETS

"Small Bite—Big Load"

LIFTING and transporting these two huge steel castings (each weighing 4000 pounds), is everyday work for this STEARNS Lifting Magnet at the Maynard Electric Steel Casting Co., Milwaukee. This 45" diameter circular magnet is one of a team of STEARNS Lifting Magnets used throughout the cleaning room and foundry whenever castings have to be moved — doing the job efficiently and economically year in and year out.

If you handle castings, borings, turnings, pig iron, strip steel, rails, slabs, billets or scrap iron, there's a STEARNS Lifting Magnet EXPERIENCE ENGINEERED to help you save time and money. For the efficient handling of flat steel sheets, plates and bars, be sure to investigate STEARNS Rectangular Lifting Magnets.

STEARNS Lifting Magnets are available in standard sizes in both bolted and all welded constructions. Special sizes and shapes made to meet your requirements.

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U. S. STEEL COMMITTEE TO STIMULATE RESEARCH

▲ The United States Steel Co. has created a research policy committee as a means of placing increasing emphasis upon research in the mining, manufacturing and distributing subsidiaries of United States Steel Corp.

Dr. R. E. Zimmerman, vice president and director of United States Steel Co., who has had many years of experience in research and technology in the steel industry, has been named chairman of the new research policy committee. The other members of the committee are: C. F. Hood, D. F. Austin, R. M. Blough, M. W. Reed, G. W. Rooney, all executive vice presidents of United States Steel Co.; and H. B. Jordan, president, American Steel and Wire Co.; Alden G. Roach, president, Columbia Steel Co.; Walther Mathesius, president, Geneva Steel Co.; J. E. Goble, president, National Tube Co.; A. V. Wiebel, president, Tennessee Coal, Iron and Railroad Co.; and Dr. E. C. Bain. Dr. J. B. Austin, director of research, United States Steel Co., will act as secretary.

Dr. E. C. Bain was elected vice president, research and technology of United States Steel Co. Dr. Bain has been prominently associated with research in United States Steel for 23 years and was most recently a vice president of Carnegie-Illinois Steel Corp., one of the companies forming the newly organized United States Steel Co.

Dr. Zimmerman, in discussing both the long range and immediate objectives of the research policy committee, emphasized particularly the increasing need for research brought

about by the national emergency, the scarcity of various alloying metals and other strategic materials, and the growing complexity of military requirements. New and special types of steel, properly processed, are needed for the most modern types of military equipment.

The further utilization of the vast low-grade iron ore resources in the United States, in which research has been conducted for many years, will be pushed forward even more vigorously under new research programs.

In pointing out that the contemplated research programs should provide additional means of aiding in the solution of problems involved in meeting both military and commercial requirements for steel, Dr. Zimmerman said the peak expenditures for research and development in 1950 would undoubtedly be exceeded in 1951. He said that the research policy committee would stimulate research and development, and would aid in the formulation and coordination of research programs and budgets.

LONE STAR STEEL NAMES GENERAL CONTRACTOR

▲ Brown & Root, Inc., Houston engineering and construction firm, was named as the low bidder on the general contract covering erection of Lone Star Steel Co.'s $73,500,000 completely integrated steel mill to be built at the concern's existing East Texas works.

Terms of the Brown & Root bid were not revealed, but it was indicated that it was made on a cost-plus-fixed-fee basis. Fieldmen of A. J. Boynton Co., consulting engineering firm of Chicago, already are working at the East Texas site. Surveyors are laying out the big plot of ground set aside for the steel mill and pipe plant.

A tentative agreement has been reached with the American Bridge Co. for construction of buildings required in the expansion.

CONSTRUCTION BEGUN ON FAIRLESS WORKS

▲ Benjamin F. Fairless, president of United States Steel Corporation, turned the first spadeful of earth on March 1 to start construction of the big new Fairless Works of United States Steel south of Morrisville, Pa., across the river from Trenton, N. J. Heavy earth-moving equipment immediately went into operation to meet the tight schedule calling for completion of this 1,800,000 ton capacity steel plant by the end of 1952. Certain of the facilities are expected to be in operation before the close of this year.

Numerous national, state and local officials, high-ranking members of the armed services, and other guests attended the ground-breaking ceremonies. The federal government was represented by Charles E. Wilson, director of the Office of Defense Mobilization.

John S. Fine, governor of Pennsylvania, Alfred E. Driscoll, governor of New Jersey, and Simon K. Moyer, chairman of county commissioners of Bucks County, Pa., made speeches to welcome the construction of Fairless Works.

Among principal United States Steel officials also present were Irving S. Olds, chairman of the board, and

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For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

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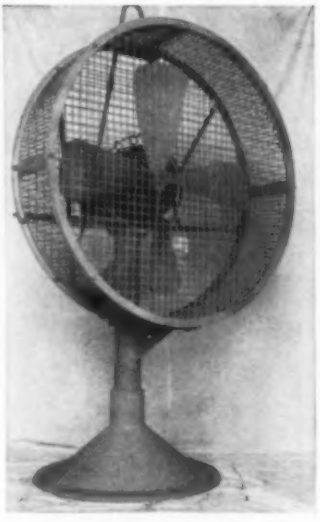

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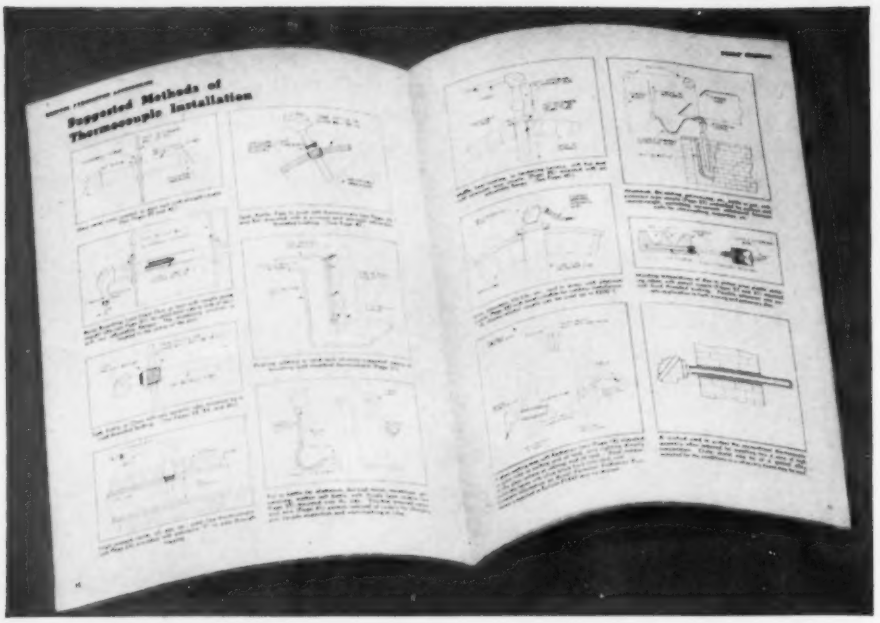

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

W. A. Irvin and Alexander C. Nagle, members of the board of directors.

Mr. Fairless was introduced by C. F. Hood, executive vice president-operations of United States Steel Co. In a brief address, Mr. Fairless spoke of the national and even international significance of the building of the big new steel works on the bank of the Delaware River.

ITALIAN MILL ORDERS ELECTRICAL EQUIPMENT

▲ A two million dollar order for steel mill electrical equipment has been placed with International General Electric Co., Inc., by the Societe Italiana Accierie Cornigliano in Genoa, Italy.

Company engineers said this is the largest single order for G-E steel mill equipment ever received from Italy. Electrical equipment to be furnished for the four cold mills will provide a total connected main drive of nearly 20,000 hp.

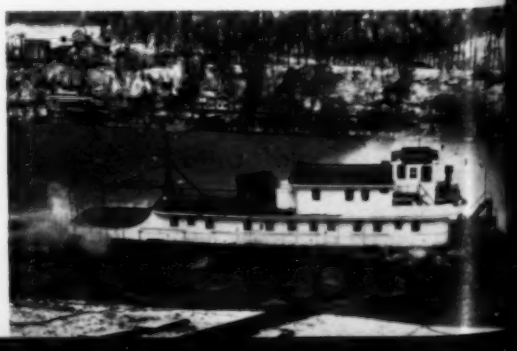
The mills will be located on a 1,200,000 sq yd section of the Genoa port which now is being filled in as part of the Italian firms' plant expansion program.

Electric equipment to be built in the United States by General Electric Co. includes main drive motors, generators, complete a-c and d-c control, switchgear, a-c and d-c auxiliaries and filters for recirculating ventilating equipment.

Compagnia Generale di Elettricita in Italy will provide the large synchronous driving motors for the main motor-generator sets, the recirculating downdraft ventilating equipment except for filters, and the installation drawings.

CRUCIBLE BOAT LAUNCHED

Into the Ohio River at Dravo Corp.'s Neville Island shipyard goes one of seven new 1066-hp diesel towboats being built by the company for the Pittsburgh district river coal trade. This vessel is the Crucible, to be operated by the Crucible Steel Co. of America.



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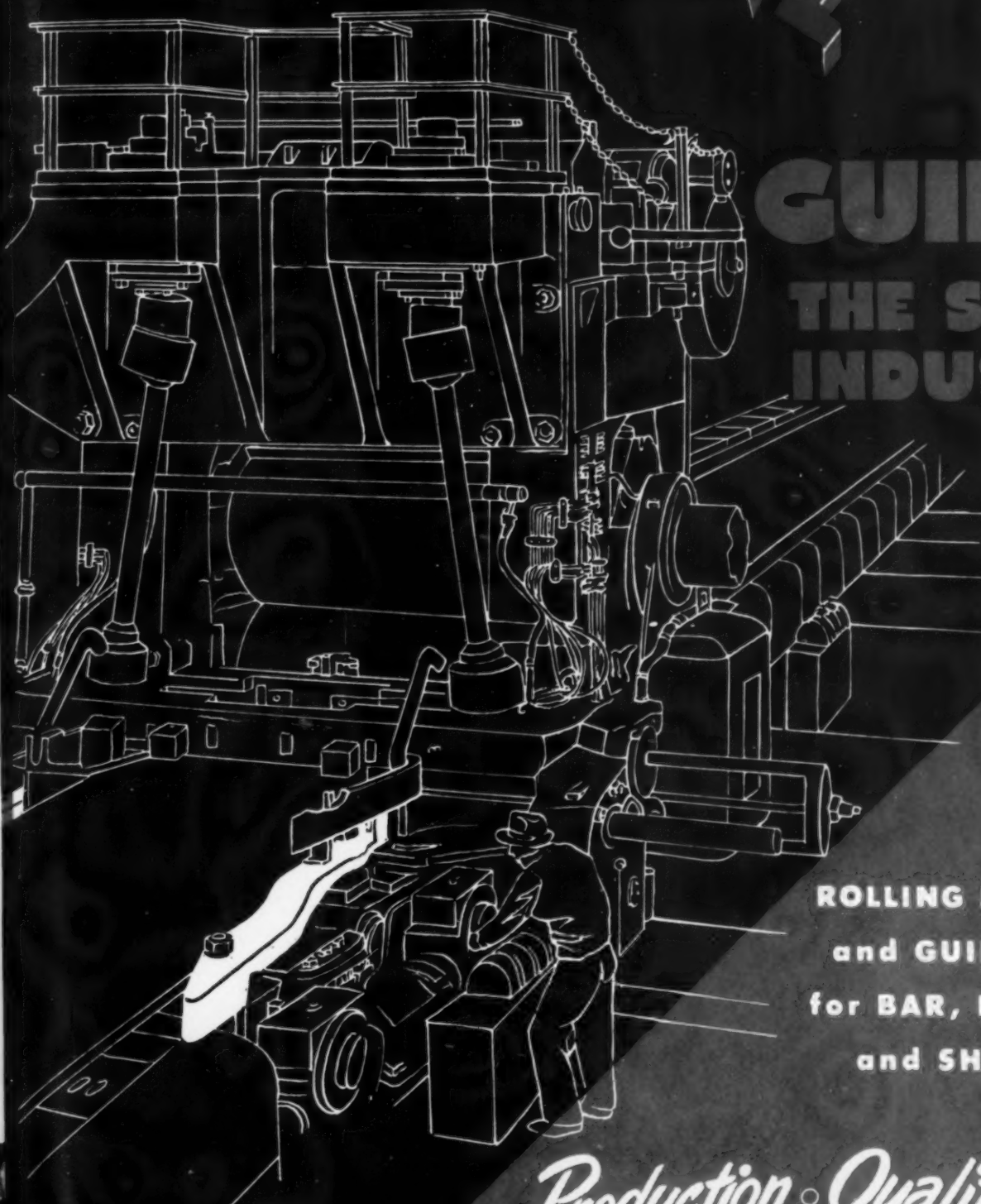

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FORD MOTOR AWARDS CONTRACT TO KOPPERS

▲Ford Motor Co. has awarded Koppers Co., Inc., a contract for the design and construction of a battery of 37 chemical recovery coke ovens and additions to its coal chemicals plant. The 37 new Koppers-Becker ovens, gun flue type, will furnish metallurgical coke for making additional iron for new Ford foundry facilities. Ford is building a production foundry in Cleveland to serve its new engine plant there, a new specialty foundry at River Rouge, and is expanding its Dearborn iron foundry. The new coke battery will produce both blast furnace and foundry coke.

Expected to be placed in operation in early 1952, the new ovens will be equipped with double collecting mains similar to those on the three coke batteries, each consisting of 61 Koppers ovens, now in operation at the Ford plant. The additional ovens will increase the plant's coke producing capacity from 1,225,000 to 1,430,000 tons per year.

The coal chemical and benzol plants will be enlarged to accommodate the increased coal chemical production from the new battery of ovens.

DETROIT STEEL TO EXPAND AT PORTSMOUTH

▲Detroit Steel Corp. has announced a $50 million expansion program to double ingot capacity and to increase by more than 50 per cent finishing capacity of its Portsmouth, Ohio, works.

Plans call for boosting ingot capacity from 600,000 to 1,290,000 tons annually and for increasing finishing capacity from 180,000 tons to over one million tons. New facilities to be constructed include a second blast furnace rated at 1,400 tons, four additional open hearth furnaces of 250 tons capacity each, a new blooming mill, a new hot strip mill and a new cold rolled sheet mill and additional soaking pits, annealing furnaces and related equipment.

Existing Portsmouth facilities include an 800-ton blast furnace, ten 105-ton open hearth furnaces, a battery of 108 by-product coke ovens, an extensive by-product recovery plant, a bar mill, a continuous rod mill and wire drawing equipment.

improved

SOAKING PIT CRANE

with MULTI-PURPOSE tongs

● Here's a rugged, lighter weight Soaking Pit Crane that handles any width slab or ingot. It'll make bottom . . . afford the same visibility as the high rack type Soaking Pit Crane, yet takes up no more head room than a low type Soaking Pit Crane.

Special features include: telescopic ram, all operating mechanism located on deck of trolley, operator's cage on deck of trolley provides best visibility and greatest distance from all sources of heat.

Multi-Purpose Tongs provide gripping range of 6" minimum to 66" maximum opening. Consequently, a much greater range of ingot and slab sizes can be readily handled.

The Multiple Range Tongs can be installed on any model or make of Soaking Pit Crane by Alliance Engineers who will be happy to discuss your specific requirements or give you general information of interest to your industry.

- MAXIMUM RANGE CAPABILITIES
- CRANE REQUIRES MINIMUM SPACE
- AFFORDS MAXIMUM VISIBILITY
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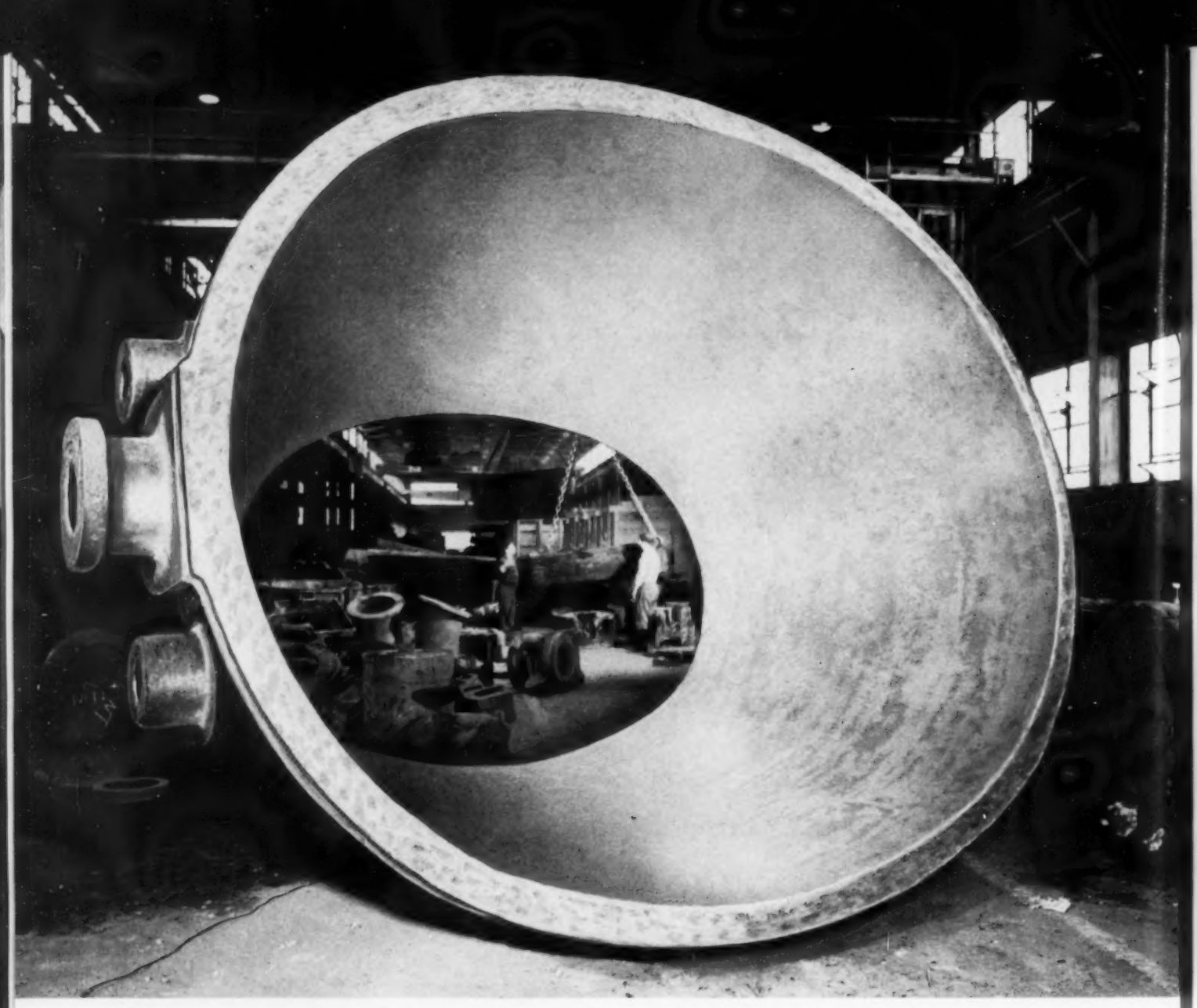

THIS SLAG POT WILL EXCEED NORMAL "LIFE-EXPECTANCY"

Whether it's a slag pot or any steel casting, unusual stresses, strains, shock, abrasion, fatigue—are all considered before "Union" makes a mold or pours a heat.

So, whatever the size, configuration, quantity, or metallurgy involved; "Union" always comes through with exactly what the customer requires —*plus* an extra measure of quality due to casting practices and techniques developed and acquired in over fifty years' experience.

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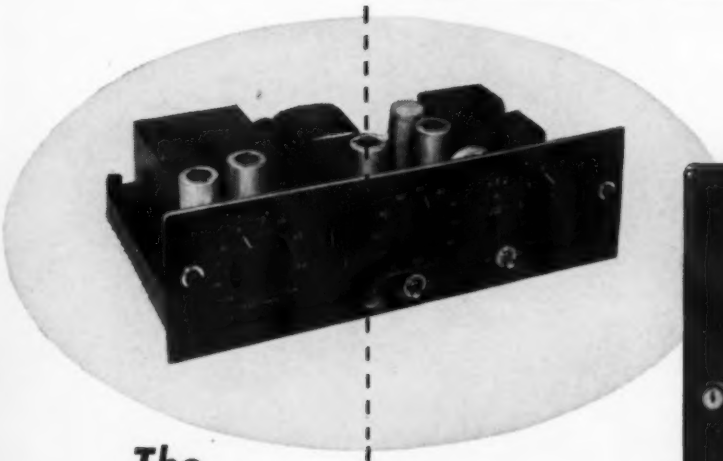
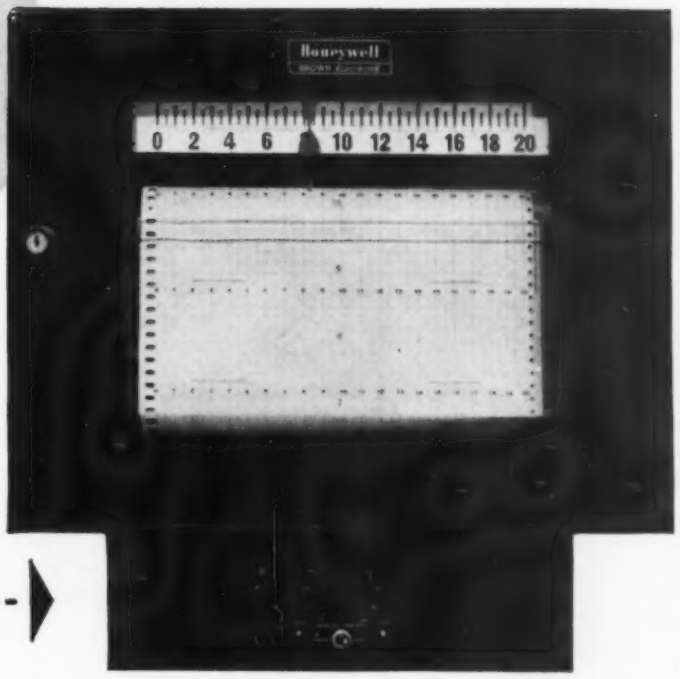
FOR PULSE FIRING OF YOUR FURNACE





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- √ **COMPACT DESIGN** *Two instruments with integral relays fit on a 24" x 42" panel.*
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- √ **AUTOMATIC RESET** *Compensates for load changes automatically.*

Write for Specification Sheet 195

You can obtain more accurate furnace control with the *Electr-O-Pulse* proportional control relay. It proportions the *on-time* of a contactor, solenoid, or motor valve in accordance with furnace demand . . . delivers an average heat input by changing the ratio of "on" to "off" time.

With automatic compensation for load changes, straight line control on an on-off basis is realized. It is equally adaptable to electric or fuel fired furnaces, and is particularly advantageous where furnace or burner design requires full heat input for proper heat distribution.

The *Electr-O-Pulse* relay may be used as an integral part of any *ElectroniK* electric proportional controller, or as a separate unit for improving performance of existing installations. Check the list of outstanding features . . . then call in your local Honeywell engineer for a discussion of how they will benefit your plant. Branch offices in more than 80 principal cities of the United States, Canada, and throughout the world.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4464 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

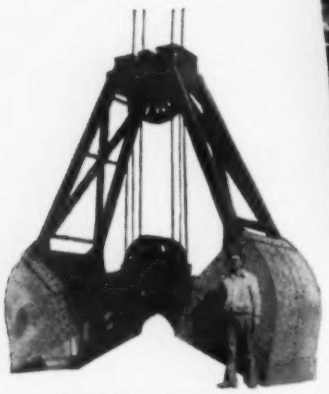
Wellman will build it

Special Cranes
Ore Bridges
Gas Producer Plants
Charging Machines
Industrial Furnaces
Car Dumpers
Gas Flue Systems
Gas Reversing Valves
Coke Pushers
Mine Hoists
Skip Hoists
Clamshell Buckets

Wellman Ore and Coal Handling Bridges

For fast and efficient action

One of two 6-ton Coal Handling Bridges in this installation.



6-ton Wellman Williams Type Coal Bucket used with these bridges.

• Take advantage of Wellman's long experience in designing and building handling bridges in many types and capacities. Your selection from the complete line will provide fast and efficient handling of coal or ore.

THE WELLMAN ENGINEERING COMPANY

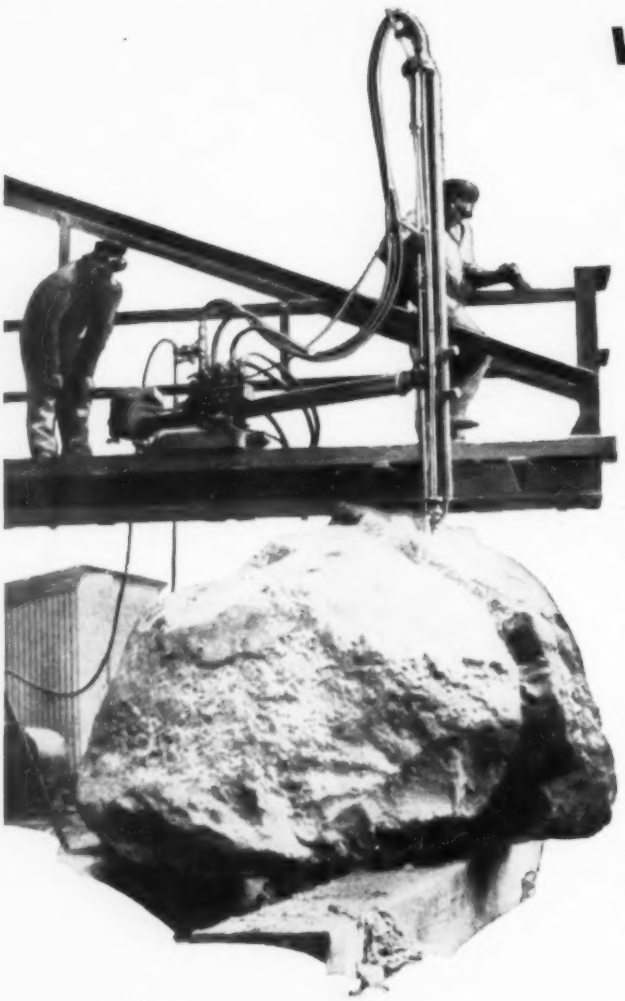
7031 CENTRAL AVENUE • CLEVELAND 4, OHIO

Body Forms
PEAKS OF FASHION
IN SHEETS OF STEEL
In modern hot-mills, which produce the vast tonnages of body-sheets, you'll find the familiar *yellow-striped red wabbler* NIRONITE *rolls*—developed by Mack-Hemp engineers and metallurgists to perform the productioneering tasks in present-day continuous mills.
Since 1900, when motor car manufacturers' requirements became a major factor in steel tonnage, Mack-Hemp engineers have matched the constant improvements in mills with striped red wabbler rolls which are the working tools in the production of a substantial portion of the current 2,448,418 net tons of hot-rolled sheets consumed annually by the automotive industry alone.
As always, Mack-Hemp is keeping pace with developments in mills and rolling techniques. It's that progressive alertness that makes it worthwhile, always, to keep an eye on what's new at Mack-Hemp.
MACKINTOSH-HEMPHILL
COMPANY
Makers of the Rolls with the Striped Red Wabblers
PITTSBURGH AND MIDLAND, PA.
MACKINTOSH-HEMPHILL PRODUCTS INCLUDE:
rolls . . . steel and special alloy castings . . . completely integrated strip mills . . . heavy duty engine lathes . . . the new Mackintosh Rotary straighteners . . . improved Johnston patented corrugated cinder pots and slag-handling equipment . . . shape straighteners . . . end-thrust bearings . . . shears . . . levellers
PLATE TOO!
If you switch to rolling plate, you'll be more than glad you're using these NIRONITE ROLLS because they will produce superior plate finishes with fewer roll changes.

Get in ALL Your Scrap---Profitably

with OXWELD Equipment

Trade-Mark



Here's the OXWELD *C-60 Cutting Blowpipe in action . . . slicing up a steel button 6 ft. thick with ease!*

Oxygen cutting rapidly converts steel sections of every size, shape, and type into good, usable scrap. Any thickness is easily reduced to charging-box size with OXWELD equipment. And no job is too tough. Whatever your scrap-cutting problem, there's an OXWELD blowpipe to solve it efficiently and economically.

For the extra-heavy jobs, the OXWELD C-60 Cutting Blowpipe with powder-cutting attachment is the answer. Especially engineered for cutting spills and ladle skulls, this combination easily makes continuous cuts through 6 ft. of dirty, slag-incrusted steel.

Other highly adaptable OXWELD blowpipes speed up medium scrapping operations. Mounted on portable, lightweight machines, they work on a production basis, cutting ingots, castings, and risers into sizes convenient for charging into the furnace.

On the lighter jobs, sturdy OXWELD hand-cutting blowpipes ready steel scrap up to 12 in. thick for the charging box. With 57 different nozzles to choose from, you get maximum efficiency at lowest overall cost.

LINDE has accumulated a vast amount of practical experience in helping to solve many unusual scrapping problems. If you have a scrap-cutting problem, ask our nearest office for help. We have the know-how, the "show-how," and everything you need to do the job profitably.

The term "Oxweld" is a registered trade-mark.

LINDE AIR PRODUCTS

A Division of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N.Y. UCC Offices in Other Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

A lightweight OXWELD *portable machine speeds this scrap-cutting operation. Setup is semi-automatic and portable . . . can be easily moved from one job to another.*

Spills, salamanders, and other mill scrap can be cut quickly and efficiently with an OXWELD *hand-cutting blowpipe . . . and with minimum gas consumption.*

OVER 9 MILLION TONS AND STILL IN SERVICE!

A WORLD'S RECORD FOR "TOOL STEEL PROCESS" SCREW DOWN SCREWS ESTABLISHED ON 46" BLOOMING MILL AT INLAND STEEL CO.

"TOOL STEEL" PRODUCTS ARE GUARANTEED TO GIVE LONGER LIFE THAN ANY OTHER PRODUCTS IN THE SAME SERVICE!

WRITE TODAY FOR COMPLETE INFORMATION.

THE TOOL STEEL GEAR & PINION CO.
CINCINNATI 16, OHIO, U.S.A.

Y&M EQUIPS THE NATION'S STEEL MILLS to Speed Production

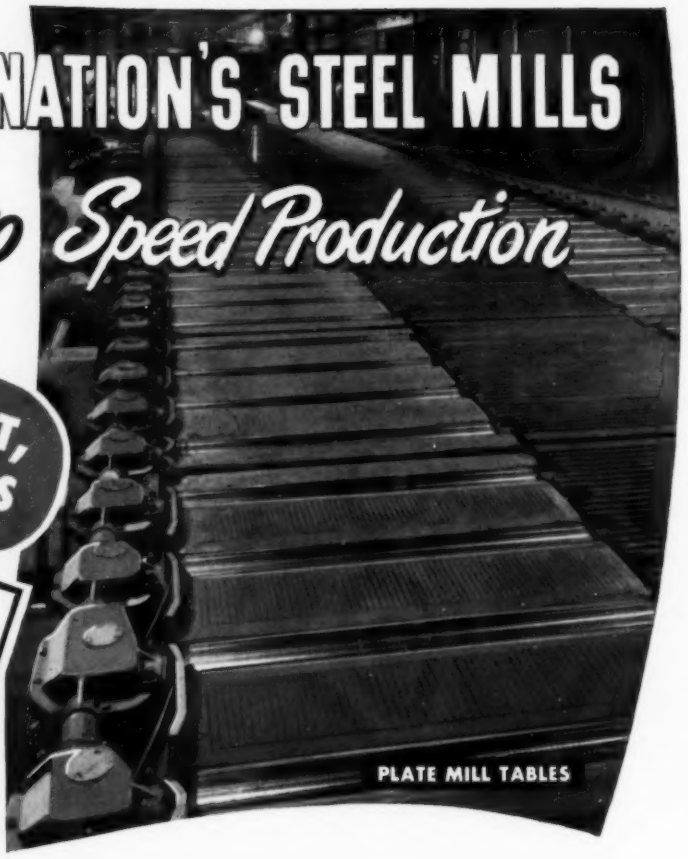
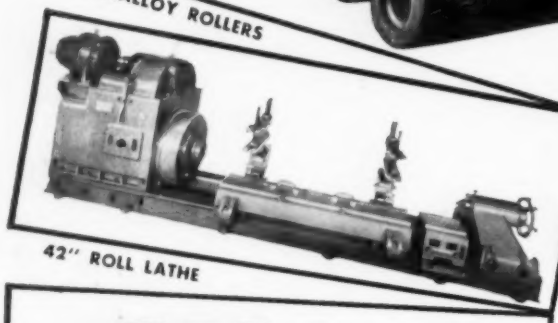
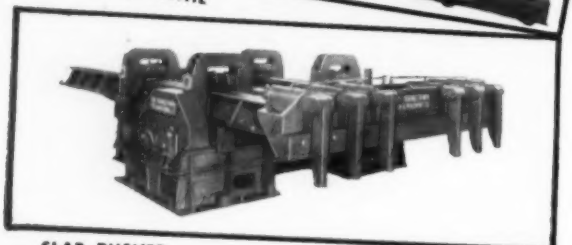


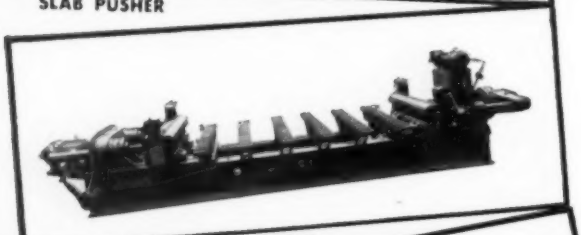
PLATE MILL TABLES

MACHINES, EQUIPMENT, ROLLS AND CASTINGS

PARALLOY ROLLERS


42" ROLL LATHE


SLAB PUSHER


90" x 240" STRETCHER LEVELER

100" SCRUBBER LINE

Check this List for the Products You Need

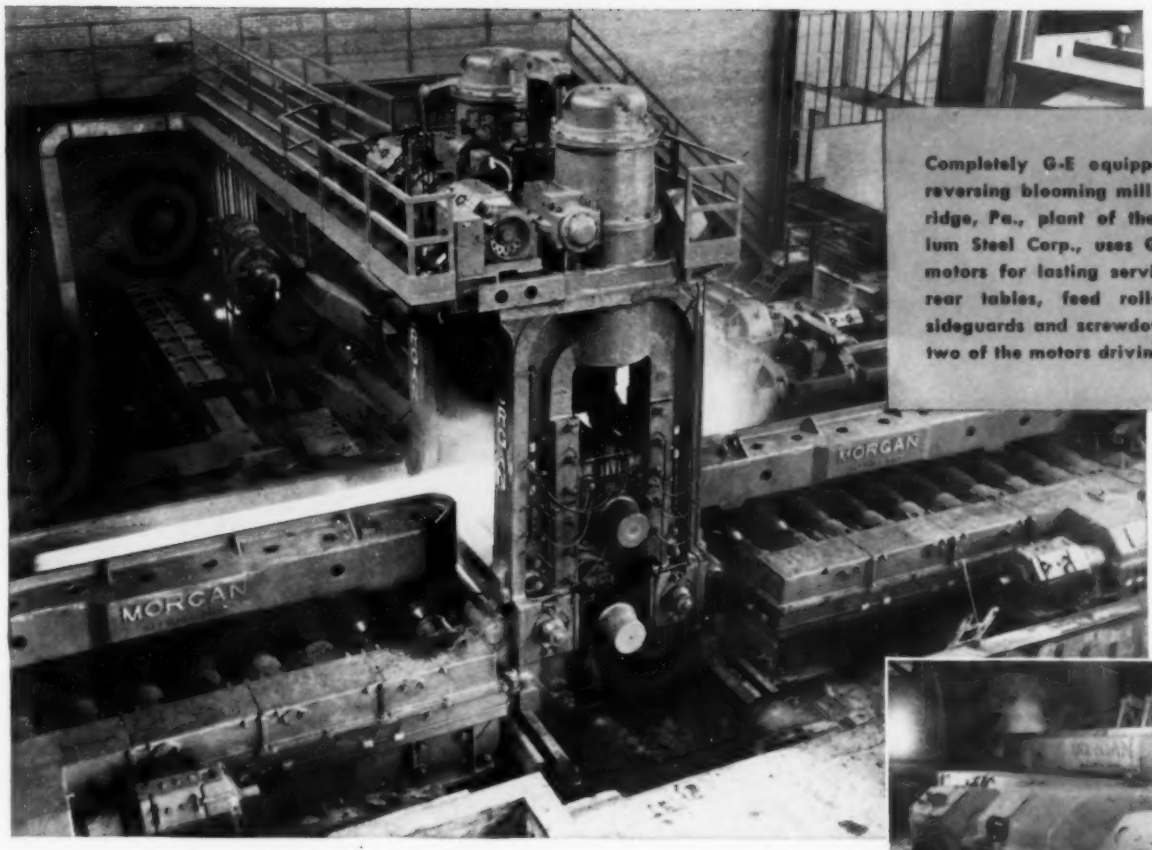
- PARALLOY ROLLS (Pinch, Coiler, Tension, Steel Mill)
- HYDRAULIC SLAB AND BILLET PILERS
- STRIP AND SHEET OILING EQUIPMENT
- SHEET SCRUBBER AND CLEANING LINES
- HOT SAWS—ROCKING AND SLIDE TYPES
- HOT BEDS—COOLING BEDS—TRANSFERS
- BILLET EJECTORS—PINCH ROLL STANDS
- SLITTERS—SPECIAL SHEARS AND GAUGES
- TILTING TABLES—Traveling and Lifting Tables
- Continuous PICKLING Lines—ROLLER LEVELERS
- FURNACE Charging Equipment—Furnace Pushers
- Strip Steel COILERS and REELS—SCRAP BALLERS
- RAILROAD Spike Forming Machines—ROLL LATHES
- Sheet GALVANIZING Lines—Wire Patenting Frames
- Stretcher Levelers—Angle and Shape Straighteners
- Rolling Mill Tables—Gear and Individual Motor Types
- DUCTILE CASTINGS (80,000 PSI.)

Machinery Built to Customer's Design and Detail Drawings

The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio



Completely G-E equipped, this 40-inch reversing blooming mill at the Brackenridge, Pa., plant of the Allegheny Ludlum Steel Corp., uses G-E MD-600 mill motors for lasting service on front and rear tables, feed rolls, manipulators, sideguards and screwdowns. Inset shows two of the motors driving the front table.

OUTAGE TIME CUT

in 40" reversing blooming mill!

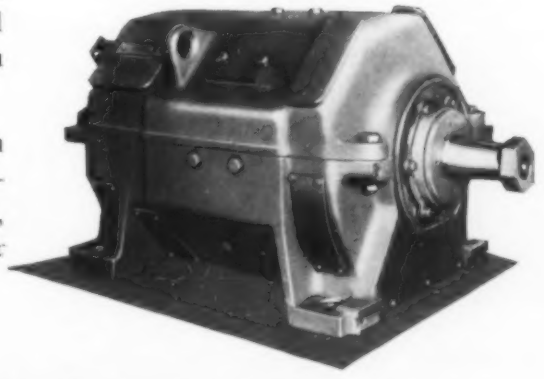
G-E d-c mill motors give day-in day-out dependability on essential auxiliaries

Here's why: Rugged construction throughout safeguards these G-E MD-600 mill motors against all kinds of steel-mill conditions. They're protected against heat of furnaces and hot metal—against mechanical shock and strain—against dirt, corrosive fumes and excessive moisture—against the effects of frequent starting, stopping and reversing. Motor life is longer, replacements fewer!

Further lengthening their service life is improved ventilation that dissipates up to 50 per cent more heat, plus mica, glass, and silicone resin insulation. Besides, compact design gives you more hp per frame size than in former types.

Here's more: G-E MD-600 d-c mill motors are available in standard mill ratings from 7½ to 200 hp to meet AISE specifications. For a detailed description of their many long-life features, write for Bulletin GEA-4654. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

MD-600 MILL MOTORS



GENERAL ELECTRIC

659-79

NOW SAVE 2 WAYS

not only by—REDUCED PRICES

but also thru—

LOWER MAINTENANCE COST

To the savings made by the reduction in "Karbate" brand impervious graphite pump prices (up to 33%), add the all-important factor of *very low annual maintenance cost.* Our records show some pumps in service for years, requiring practically no replacement parts.

Specify "KARBATE" BRAND

Impervious Graphite Corrosion Resistant

PUMPS

HERE'S WHY—

- Case and Impeller are of "Karbate" impervious graphite — they do not corrode.
- Stainless Steel Shaft, where exposed to corrosive fluids, protected by "Karbate" impervious graphite.
- "Karbate" impervious graphite rotary seals* are regular equipment — included in basic pump price. They are not "extras".
- No stuffing gland to require packing — a single, occasional adjustment of the "Karbate" rotary seal replaces this cost.

Other NATIONAL CARBON products

*Now, even at new low pump prices, "Karbate" rotary seals have been improved. Teflon is used to gasket the seal to the shaft and the gasket is adjusted, independently of pressure, on the seal faces.

OTHER FEATURES:

- All-purpose application
- Freedom from product contamination
- Excellent corrosion resistance
- Rugged construction
- Low maintenance — minimum servicing and replacement of parts

The term "Karbate" is a registered trade-mark of

NATIONAL CARBON DIVISION
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
In Canada: National Carbon Limited, Toronto 4

BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • SKIMMER BLOCKS • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS • TANK HEATERS

Personnel News...

James W. Kinnear, Jr. has been appointed assistant to vice president-manufacturing of United States Steel Co., Pittsburgh, Pa. Mr. Kinnear returns to U. S. Steel after a four-year absence. During this time he was president of Firth-Sterling Steel and Carbide Corp., having resigned this position the first of the month.

Herbert B. Nechemias was recently appointed manager of the industrial sales department at Wagner Electric Corp., St. Louis, Mo., succeeding **J. S. Smith** who was appointed director of purchasing. Mr. Nechemias joined Wagner in 1938 as a student engineer and spent 12 years in the sales department prior to his promotion.

Dr. Bruce S. Old was elected vice president of Arthur D. Little, Inc., Cambridge, Mass. Dr. Old has been with the company since 1946, in charge of process metallurgy, and has been a director since 1949.

W. A. Morton has been named president of Loftus Engineering Corp., to succeed the late Fred H. Loftus. Mr. Morton, who joined the firm in 1949, was previously president of Amsler-Morton Co., a position he held for 20 years.

Clem W. Gottschalk was named to the position of assistant vice president-traffic, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

H. George De Young was named works manager, Atlas Steels, Ltd., Welland, Ontario, Canada. Mr. De Young was formerly assistant to president, Treadwell Engineering Co., Easton, Pa.

King Christopher, formerly connected with the Philadelphia district office of Clark Controller Co., has been moved to Los Angeles, Calif., as district manager. Other changes in the Clark organization are as follows:

Bruce Harmon, and **W. J. Bergen, Jr.** have joined the Cleveland, Ohio, district office; **Cloud M. Conklin, Jr.** joins the Youngstown, Ohio office, **Dave DeHerder,** the Chicago, Ill., office, and **John T. Casey** goes to the Buffalo, N. Y., office; **Burl G. Robertson** is assigned to Birmingham, Ala., and **Fred F. Piper, Jr.** to Pittsburgh, Pa.; Arthur B. Sonneborn Co., Detroit, Mich., area representative for Clark has added **Norman G. Dembroeder** to the Toledo, Ohio, office, and **Robert W. Brisky** to the Grand Rapids, Mich., office.

S. Frederick Magis was elected general manager last October 30 for Siderurgica Venezolana "Sivensa" S.A. Caracas, Venezuela. He formerly was consultant on production of steel and finished steel products.

Morris L. Hicks was named manager of the Philadelphia district office of Dravo Corp., Pittsburgh, Pa. Mr. Hicks has been sales manager for the Dravo's engineering works division.

Amos C. Bledsoe has been named division superintendent, sheet and tin, at the new Fairless works of United States Steel Co., Morrisville, Pa. Other appointments are as follows: **John F. Brownlee,** superintendent, production planning; **Kermit L. Johannsen,** division superintendent, central maintenance and utilities; **Theodore J. Koenig,** division superintendent, rolling; **Fred B. Lafferty, Jr.,** superintendent, industrial relations; **Emerson R. Miller,** division superintendent, blast furnaces, coke ovens and by-products; **Maynard J. Rich,** plant industrial engineer; and **Lester R. Walker,** chief metallurgist and inspector.

Dr. John F. Thompson, president of International Nickel Co., of Canada, Ltd., was elected to the additional office of chairman of the board of directors, succeeding the late **Robert C. Stanley. Dr. Paul D. Merica,** executive vice president and a director, was elected a member of both the executive committee and the advisory committee of the company.

W. G. Miller was appointed manager of manufacturing for Westinghouse Electric Corp.'s motor and control division, Buffalo, N. Y. Mr. Miller, who has been serving recently as assistant works manager, will have charge of all manufacturing operations, except in the copper department and factory service.

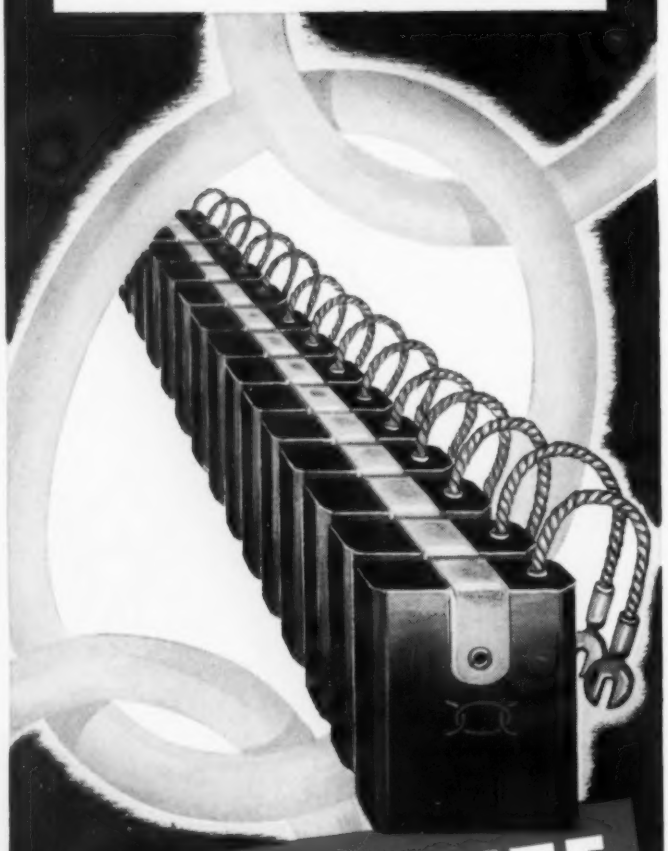
Edwin J. Heimer was appointed sales manager of hand lift and motorized hand trucks made by the Philadelphia division of Yale & Towne Manufacturing Co.

Charles Bangert, Jr. has been appointed manager of engineering for the Trumbull Electric Mfg. Co., in Plainville, Conn. Mr. Bangert joined Trumbull in 1947 as designing engineer and was appointed product planning manager under the marketing department in February 1950.

J. J. Pascher was named district sales manager of

AMES W. KINNEAR, JR. | HERBERT B. NECHEMIAS | DR. BRUCE S. OLD | W. A. MORTON

Link YOUR COMMUTATION TO THE RIGHT
MORGANITE
brush grade



MORGANITE
CARBON BRUSHES

The wide range of MORGANITE brush compositions is an important aid when selecting a brush to meet a specific motor or generator operating condition. Equally helpful is the wide experience of MORGANITE engineers who will gladly assist in determining your proper brush grade.

Morganite
INCORPORATED
LONG ISLAND CITY 1, NEW YORK

Manufacturers of Morganite Self-Lubricating Carbon Specialties including Seals, Rings, Valves, Slides, Bearings, etc., and Carbon Piles

Trumbull Electric Mfg. Co.'s New York district. Mr. Pascher has been manager of the Hartford office of the General Electric Co. since February 8, 1945, and prior to that was sales engineer in the industrial division of the apparatus department's New York office.

E. D. Youmans was named vice president in charge of manufacturing and research for Oakite Co., Passaic, N. J.

W. A. Edwards has been appointed district manager of the Trumbull Electric Manufacturing Co.'s east central district, with his headquarters at Norwood, Ohio, works.

Robert H. Owens has been elected president and general manager of Roots-Connersville Blower Corp., succeeding **John Avery** who died recently.

Tomlinson Fort, who is manager of Westinghouse Electric Corp.'s headquarters apparatus sales department at Pittsburgh, was elected vice president.

Anthony J. Zino, Jr., was named assistant to the

ANTHONY J. ZINO, JR.

president of Swan-Finch Oil Corp., New York, N. Y.

M. B. Farrar, formerly manager, special products division, Union Carbide Europa S. A. Rue de La Corraterie, Geneva, Switzerland, is now managing director of Kemet Products Co., Kent, England. Mr. Farrar was with the National Carbon division of Union Carbide and Carbon Corp. in the Pittsburgh, Pa., and Birmingham, Ala., sales offices for many years.

Ancel C. Adams was appointed general plant superintendent of Cleveland Crane and Engineering Co., Wickliffe, Ohio. Mr. Adams has been with the company for 28 years, during which time he has served as manager of the shipping, receiving, and stores department; traffic manager; and assistant plant superintendent.

J. A. O'Brien, general manager of the industrial products division of Johns-Manville Corp., New York, N. Y., was appointed vice president.

L. M. Cassidy, who has been vice president for sales of Johns-Manville Corp. since 1946, has been elected president. Mr. Cassidy succeeds **R. W. Lea** who has retired as president and director.

Clarence Lynn has been appointed engineering manager of the Atomic power division of the Westinghouse Electric Corp., Pittsburgh, Pa. Mr. Lynn, former man-

make every move count!

....to serve you better

with

Northern

Overhead Traveling CRANES and HOISTS

Quick, dependable movement of stock whenever and wherever needed is a "must" in steel warehousing. Breakdowns, idle time for maintenance and similar stoppages cannot be tolerated.

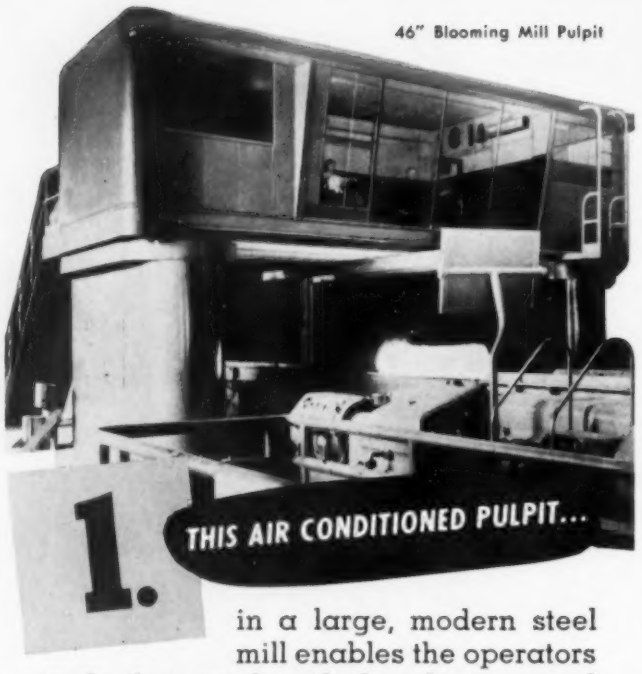
During the past fifty years NORTHERN OVERHEAD ELECTRIC TRAVELING CRANES have been installed in many warehouses where they are providing fast, continuous, uninterrupted service — meeting peak load demands—dependably responding to rugged overloading in emergencies—making every move count for better service to suppliers and their customers.

Write for Bulletin 150-C

NORTHERN ENGINEERING WORKS

General Offices: 2615 Atwater St., Detroit 7, Michigan

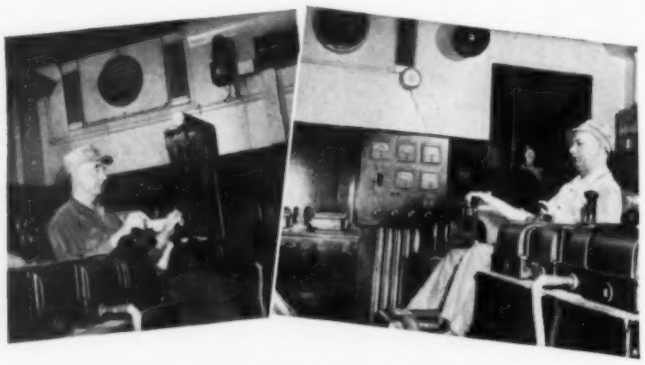
BUILDERS OF CRANES AND HOISTS EXCLUSIVELY



46" Blooming Mill Pulpit

1. THIS AIR CONDITIONED PULPIT...

in a large, modern steel mill enables the operators to do their work with the *alertness* and *skill* expected of them in maintaining capacity production.



Men work most efficiently under these conditions.

2. A UNIFORM TEMPERATURE OF 70-80° . . .

is maintained by the Lintern Aire-Rectifier. The air (cleaned and cooled) enters through the rugged, all copper cooling coils located above the men's heads; the *water-cooled* condenser is in one of the columns, easily accessible. Maintenance is a minor item. The Aire-Rectifier pays for itself over and over again in both quality and quantity of work. *Ask for Bulletin AC-149 and tell us your problem so that we can write you fully.*

THE LINTERN CORPORATION
29-2 RIVERSIDE DRIVE • BEREA, OHIO

aged of the d-c engineering department of the transportation and generator division at East Pittsburgh, has spent his entire business career with Westinghouse.

George P. Patterson has been appointed assistant to the manager of sales of General Electric's large motor and generator divisions at Schenectady, N. Y.

Robert T. Griebling, a fellow of Mellon Institute, was named executive secretary of the Air Pollution and Smoke Prevention Association of America, Inc. The headquarters of the association, hitherto located at Chicago, Ill., will be moved to Pittsburgh, Pa., and will be housed in Mellon Institute, which has pioneered in research on urban and communal smoke control since 1911.

Walter C. Mason was named director of personnel for Arthur G. McKee & Co., Cleveland, Ohio. Mr. Mason resigned his position with E. F. Hauserman Co., where he also served as the personnel director, to take over his duties with McKee.

Francis K. McCune, assistant general manager of the General Electric Co.'s nucleonics department, has

FRANCIS K. McCUNE

been appointed manager of engineering of the company's large apparatus division in Schenectady, N. Y.

Roy E. Carter, formerly chief engineer of Sharon Steel Corp., Sharon, Pa., has been made vice president in charge of engineering for Furnace Engineers, Inc., Pittsburgh, Pa.

William B. Keirn was recently appointed superintendent of the cold rolling mill and of the new tin plate mill now being constructed at the Fontana, Calif., works of Kaiser Steel Corp. With Kaiser since 1946, he also supervised the construction and operation of the cold rolling mill built during 1946 and 1947. Mr. Keirn was with the American Sheet & Tin Plate Co., Gary, Ind., now a part of U. S. Steel Co., from 1920 until 1946.

C. A. Kral, Chilean management representative for Koppers Co., Inc., at Concepcion, Chile, since September 1949, has been appointed a vice president in Koppers engineering and construction division.

J. R. Dembeck has been appointed works auditor of the new Fairless works of United States Steel Co. to be built near Morrisville, Pa.

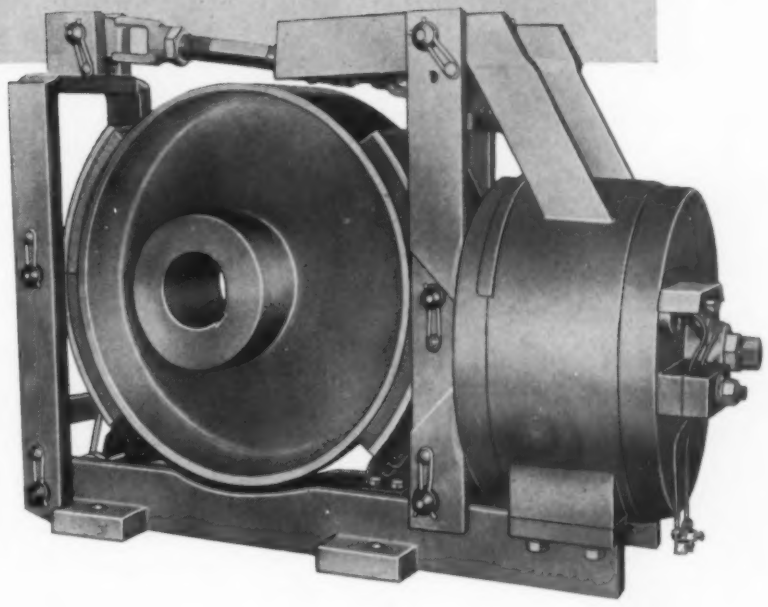
Dr. Martin A. Edwards has been appointed engineering manager of the General Electric Co.'s general en-

It's time to repeat that

CLARK

BULLETIN 106 D.C. SHOE BRAKES

are

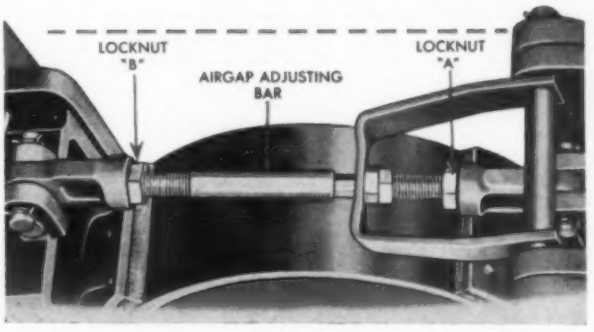


1. The only brakes with one adjustment for lining wear. And that adjustment is on the top—not on the bottom—not on the sides—not on the ends—but on TOP, where you can see it and get at it easily.
2. The only brakes designed to fit the new 600 SERIES Type Mill Motors.
3. Operated like a nut cracker—a basic principle in mechanics—resulting in equal distribution of forces, and dependable operation.
4. The simplest to adjust.
5. Very easy to install.

---and here's where----

the only adjustment needed—and that's for lining wear—is made. Right on top.

Simply loosen locknuts A and B and turn the adjusting bar until the gauge nut sleeve is again flush with the gauge rivet. With this adjustment made, the brake is returned to its original setting, automatically providing correct shoe clearance, air gap and torque setting.



Over twenty-five hundred CLARK Bulletin 106 D. C. Brakes were built during the war—hundreds more are in service on Mill installations such as Cranes, Charging Machines, Side Guards, Screwdowns, Transfer Cars, etc. and reports of outstanding performances are being received.

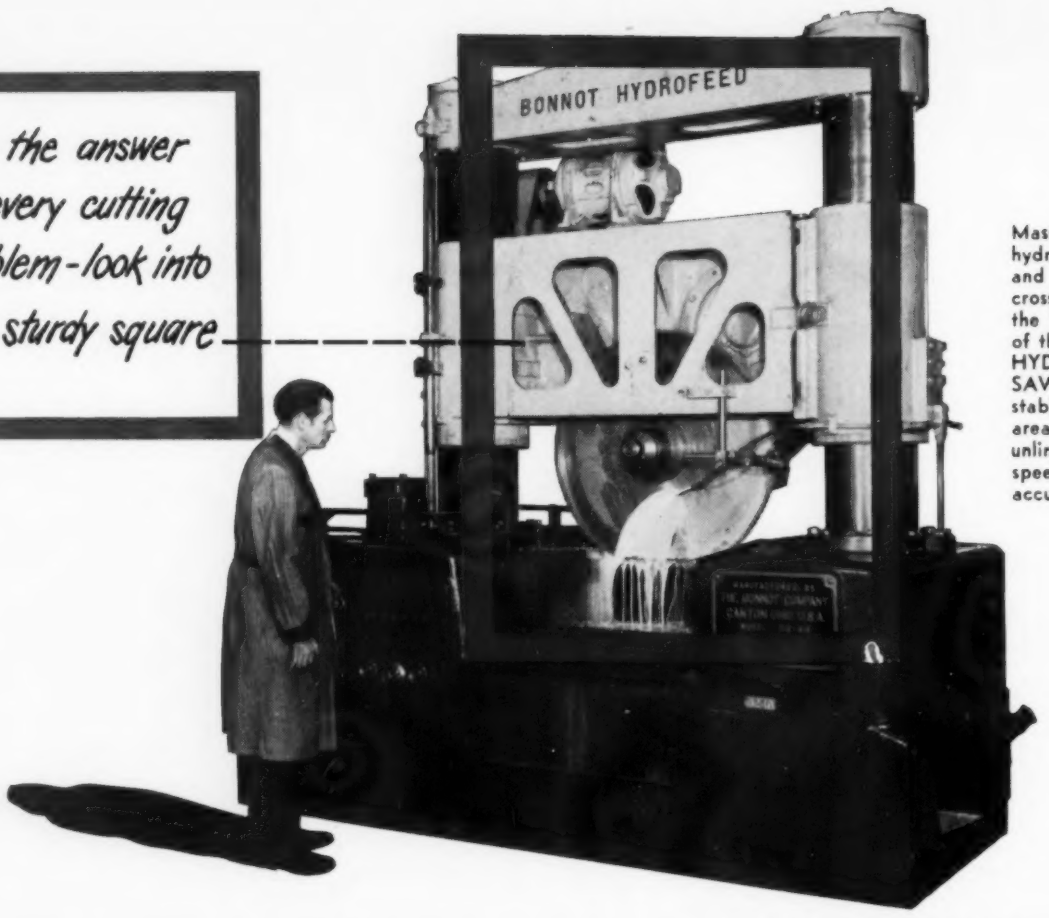
The nearest CLARK representative will gladly consult with you on your Brake problems.

EVERYTHING UNDER CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152nd STREET, CLEVELAND 10, OHIO

For the answer to every cutting problem - look into this sturdy square



Massive base, huge hydraulic columns and one-half ton crosshead enclose the "sturdy square" of the Bonnot HYDROFEED COLD SAW. This assures stability of working area that means unlimited cuts at high speeds . . . perfect accuracy every time.

IT'S THE RUGGED HEART OF THE HYDROFEED BILLET AND BAR COLD SAW!

Engineered for continuous, 'round-the-clock performance—for a vastly stepped-up output and for "sharp pencil" economy — the *Bonnot* HYDROFEED COLD SAW stands alone in modern cold-sawing techniques and efficiencies. Automatic, high speed, vertical feed, it brings you a full "baker's dozen" of advantages unmatched by any other method!

Check these Features! Count them Too!

1. POSITIVE FEED CONTROL
2. ACCLIMATED TO ALL WEATHER
3. RIGID CONSTRUCTION
4. CHATTER-FREE OPERATION
5. SAFETY CONTROLS—FOR OPERATION AND MACHINE PARTS
6. ADJUSTABLE PRESSURE CONTROL
7. CUTS WIDE RANGE OF SIZES, SHAPES AND ANALYSES
8. PERMITS SELECTION OF FEEDS AND SPEEDS
9. PROVIDES HIGH VISIBILITY FOR OPERATOR
10. HIGH SPEED CUTTING AND CARRIAGE RETRACTION
11. SELF-CONTAINED HYDRAULIC SYSTEM
12. AUTOMATIC VOLUME CONTROL
13. EASY ACCESSIBILITY FOR MAINTENANCE

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gineering laboratory. Formerly associate engineer in charge of the laboratory's technical divisions, Dr. Edwards, in his new capacity, will be responsible for all engineering activities of the laboratory and for engineering relations with other divisions and departments of the company.

John W. Oehler has been named sales manager of the

JOHN W. OEHLER

engineering works division of Dravo Corp., Pittsburgh, Pa.

USE THE ENGINEERING MART

Obituaries

W. H. Seaman, president and chairman of the board of National Roll & Foundry Co., Avonmore, Pa., died February 13. Long active in the roll business, Mr. Seaman was first with Seaman-Sleeth Co. (Phoenix Roll Works) in 1908. In 1921 he joined Hubbard Steel Foundry Co., and when it was merged to form Continental Foundry & Machine Co., he stayed with the organization and became vice president in charge of roll sales. He later joined Mesta in the same capacity, leaving there in 1940 to head National Roll & Foundry Co. Since 1948 he has also served as chairman of the board at National.

Admiral C. E. Braine, U.S.N. (Ret), assistant to the president, Crucible Steel Co. of America, died on January 12.

Robert Crooks Stanley, 74, chairman of the board of directors of International Nickel Co. of Canada, Ltd., died February 12.

Henry Plackett, 63, superintendent sheet rolling mill, Parks works of Crucible Steel Co., Pittsburgh, Pa., since 1931, died recently.

Roland J. Eckstein, 58, Cleveland district manager for Cutler-Hammer, Inc., died February 14.

W. L. Iliff, 60, manager of eastern sales, Hyatt Bearings division, General Motors Corp., Harrison, N. J., died February 3.

Heroult

ELECTRIC MELTING FURNACE

. . . as ever, the dependable furnace for the production of high-grade stainless, alloy and rimming steels.

Removable roof of new design now available for the larger furnaces.

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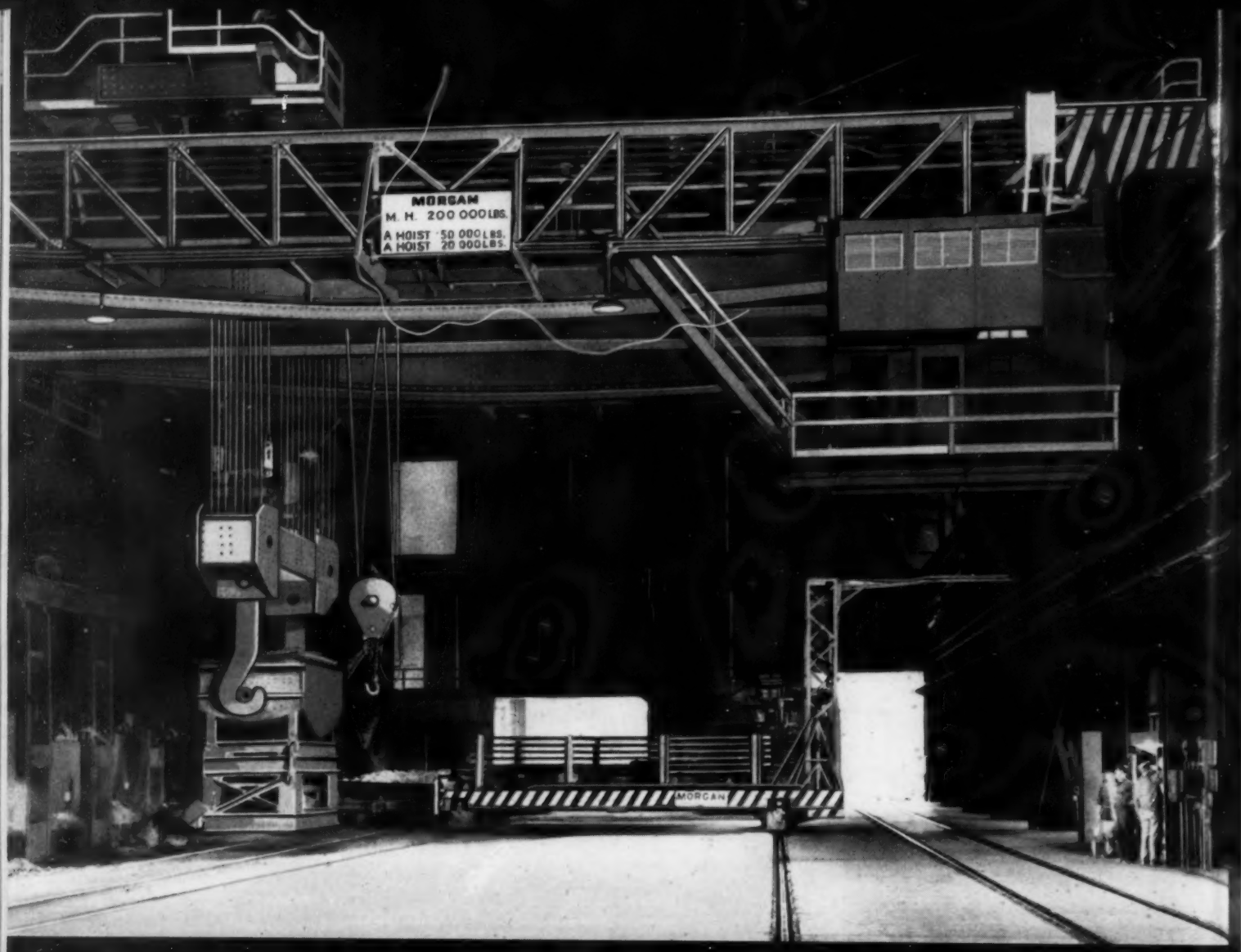
USS

AMERICAN BRIDGE

UNITED STATES STEEL



Illustrated is a 100-ton, 80'-0" span, 4-girder type Ladle Crane and a 7½-ton, 26'-0" span Floor Charger.

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Equipment News...

JET TAPPER USES EXPLOSIVE CHARGE TO TAP OPEN HEARTH FURNACE

▲ The use of explosive charges for tapping in the steel plant, which was originally done on the blast furnace, has now been applied to the open hearth. The equipment is a peacetime application of the shaped charges which were used for penetrating armor during the war in such items of ordnance equipment as the bazooka.

The tapper consists of a two ounce charge in a plastic case with a thin copper cone imbedded in one end. When detonated, the jet tapper acts as a projectile, rather than depending on blast effect, and the detonation creates a high velocity jet of copper fragments which move at extremely high velocities of 10,000 to 30,000 ft per sec. The high velocities release large amounts of energy on the tap hole facing, which in turn flows like a liquid from the path of the jet. The radial flow induced in the facing produces a hole much larger than the jet itself. The diameter of the hole depends on the target temperature. A jet which would make a ⅜-in. hole in steel at room temperature will make a 1-in. opening at 1500 F. This normally results in full flow from a jet tapped hole. The tappers will penetrate more than 6 in. of steel and Figure 1 illustrates the operation on an open hearth furnace.

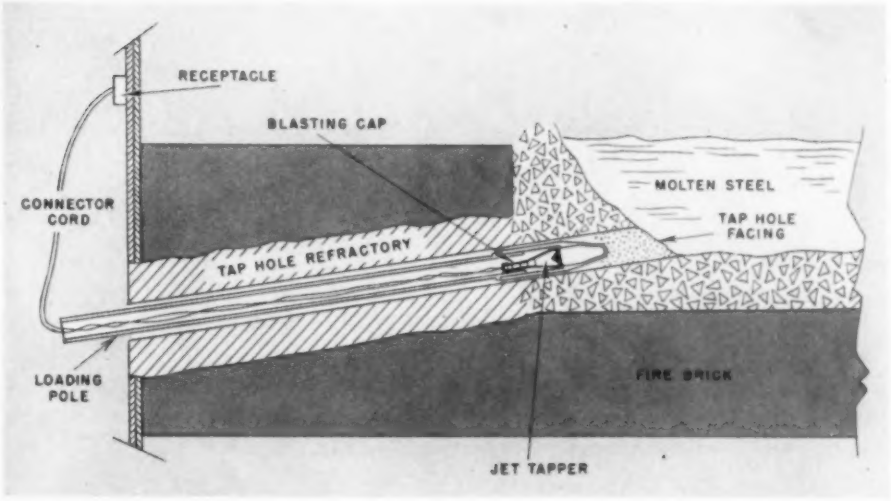
Preparation of the hole for jet tapping is the same as for oxygen lancing. It is very important, however, that all loose dolomite be cleaned out of the hole so that the tapper can be moved all the way to the back. An electrical blasting machine is used to fire the charge. The explosive is relatively insensitive to impact, friction, and other causes of accidental explosion as compared to most commercial explosives. However, it is not recommended that they be used if there is any indication that the heat may break out of its own accord, for although the cap may not detonate for at least a minute even if the assembly is floating on molten steel, this hazard should be avoided. The storage of the tappers should be in accordance with the requirements set up by the Institute of Makers of Explosives, and local and state laws which pertain to such equipment.

The advantages of the device which has been tested in actual practice for sometime by at least one steel company are as follows:

1. It is unnecessary for anyone to stand by the runner when metal starts to flow.
2. The danger of burns from faulty connections in oxygen lances is eliminated.
3. Heats can be tapped at exactly the desired time, avoiding off-specification heats resulting from delayed taps.
4. Taps start out at full flow rate, thus reducing over-all tapping time and ladle skull.
5. The uni-directional action of tappers reduces tap hole maintenance and assures perfect alignment of the tap hole.
6. The need for bars to knock down ridges in front of the hole is practically eliminated.

The equipment has recently been put on the market by the E. I. Du Pont de Nemours & Co. (Inc.), Explosives Department, Wilmington 98, Delaware.

Figure 1 — Cross-section of open hearth furnace tap hole showing jet tapper in position for firing.



RUBBER TIMING BELT IS OUTSTANDING ADVANCE

▲ United States Rubber Co. has started large scale production of a rubber and fabric belt with teeth which it considers the most outstanding advance in power transmission during the past 50 years.

Known as the Gilmer timing belt, it fulfills the need for a power drive which will not slip and permits split-second precision timing. In addition, it will attain speeds up to 16,000 fpm.

Already the new belt has replaced flat belts, V-belts, chain drives and gears in hundreds of applications as more economical and efficient means of power transmission. It can also be used as a functional part such as a synchronized conveyor as well as for transmitting power.

Perfected after 12 years of research by the L. H. Gilmer division of United States Rubber Co., the belt is similar in appearance to a flat belt except that it has regularly spaced rubber teeth along its inner surface which engage in corresponding grooves in the pulleys. It can be manufactured in any desired size and in a variety of materials to suit specific applications.

Currently production is limited to specifically engineered applications. However, the company expects to offer a standardized line of stock drives in both heavy and light duty constructions with a sufficient number of pulleys to give an adequate range of speed ratios.

In addition to its anti-slip charac-

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accurately formed

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TRADE MARK REG. U. S. PAT. OFF.

SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR *SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS* ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* ● EXCELLENT AS A CURRENT-CARRYING BEARING.

GRAPHITE METALLIZING CORPORATION

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teristic and precision timing, the new belt will not stretch. It will operate on fixed centers without take-up adjustments. Since it needs no initial tension it has unusually high efficiency with extremely low bearing pressure. Tests have shown that the belt operates more quietly than precision gears running in an oil bath.

The belt requires no lubrication. However, oil will not harm it. It is unusually compact and speed ratios up to 30:1 are possible with it. The belt's extreme flexibility permits pulley diameters as small as one-half inch at 10,000 rpm even with a heavy load.

RUST PREVENTIVE FOR METAL SURFACES

▲ A new addition to its line of "No-Rust" compounds has been announced by Gulf Oil Corp. The new product is called Gulf "No-Rust" No. 6.

The new "No-Rust" is recommended for protection of metal surfaces against corrosion in either indoor or outdoor exposure during domestic and overseas shipment and for either indoor or outdoor storage for long periods of time.

This rust preventive is of the thin film type and will provide approximate surface coverage of 390 sq ft per gallon. It has no tendency to settle or separate in storage, and due to excellent adhesion the coating when once applied and dried will not crack, chip, scale or disintegrate at temperatures down to 0 F, nor will it flow at temperatures as high as 190 F.

This new rust preventive will deposit a coating not exceeding 8 thousandths of an inch in thickness by dipping at a temperature of 70 F and will dry sufficiently within four hours to permit handling without removal of the coating.

UNIT MEASURES HEAT OF ROLL SURFACES

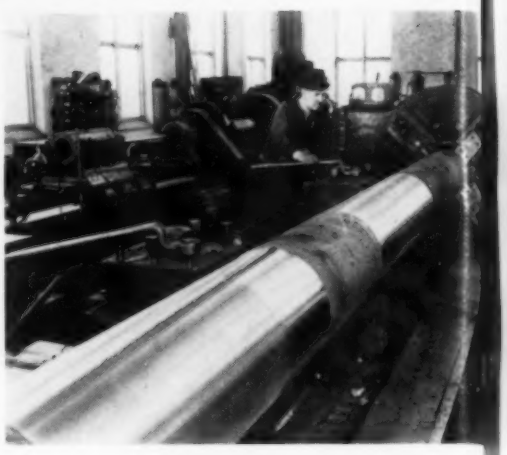
▲ A new roll surface temperature unit developed by Leeds & Northrup Co. measures temperature of a moving roll surface without touching the roll. Because of unique design, it cannot scratch, score, or in any way destroy delicate surface films. Temperature detected by the unit is recorded automatically by either a "Micromax" or "Speedomax" instrument supplied as an integral part of the complete equipment. The recorder can be equipped to operate signals or controls.

Applicable to roll diameters down to 9 in. and to flat surfaces, the new detecting unit operates independent of surface speed, emission characteristics, and finish. It can be mounted at the center of the roll or at any other location, wherever actual temperature measurement is desired.

This new primary element works on the principle that a moving object carries with it a thin, closely adhering layer of air nearly the same temperature as the moving surface. Mounted $\frac{1}{32}$ in. from the surface is a measuring head, contoured to fit the roll. A continuous stream of air is sucked past the measuring element and thus heats it to virtually the same temperature as the roll surface.

Although recorded temperature is a few degrees lower than true surface temperature, the difference remains substantially constant and is therefore negligible in process control (—4 F or less). The unit provides temperature measurements well within limits of industrial requirements. Air suction rate and surface speed are noncritical over wide limits. Measure-

SWEDISH ROLL SHOP



Typical finishing operations on Swedish-made rolls are seen in the new machine shop which was completed in 1948 by Akers Styckebruk Aktiebolaget at Styckebruk near Mariefred, Sweden. The machine shop equipment works three shifts per day in turning or grinding rolls for installation in many parts of the world. The machine operator, pictured above, is using a Mackintosh-Hemphill 44-in. screw feed lathe to turn a roll for a Swedish steel mill. This lathe works at speeds up to 39 rpm for rough turning. When turning roll necks for roller bearing mounting, the lathe meets tolerance specifications of about 5/100 of a millimeter.

ments are not appreciably affected by ambient temperature.

Compound joint with spacing slide makes it easy to position the measuring head concentric with the roll and at proper spacing. Should material adhere to the roll surface, a safety bumper retracts the measuring head. The unit can also be supplied with a safety switch which operates in conjunction with this retracting device. This safety actuates a bell, horn, or light to signal the operator and freezes the control until the measuring head is reset.

NEW STEAM PLANT USES RECIRCULATION PRINCIPLES

▲ A compact, reliable steam plant culminating a five-year period of research, development and operating experience is now being offered by Combustion Engineering—Superheater, Inc. Known as the "C-E" recirculation steam generator, it is actually a complete steam plant which includes feedwater pump and control, fuel equipment and control, combustion control and safety devices, forced-draft fan, safety valves, circulating pump and all other auxiliaries. The generator may be fired by light or heavy fuel oil or by natural gas. It is available in several sizes for steam capacities from 2800 up to 6000 lb per hr and for operating pressures up to 300 psig.

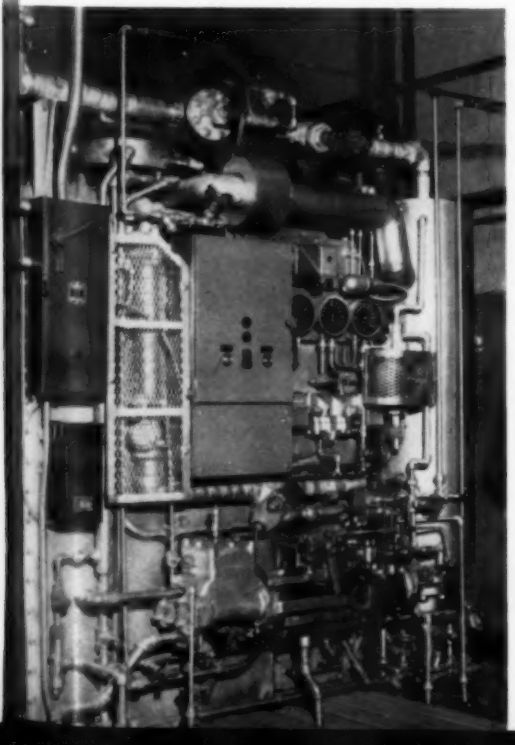
Following the successful development and application to train heating, the possibilities of the generator for the industrial field were investigated. It was concluded that various special features of the generator made it widely applicable in these fields.

The initial applications in industrial plants were made early in 1950. These were highly successful and since then a number of generators have been purchased for various types of service.

To the observer the most notable feature of the generator is its remarkable compactness. The 6000-lb capacity unit for burning light oil or gas occupies a space 6 ft 11 in. long × 5 ft 5 in. wide × 6 ft 11 in. high, and the heavy oil burning unit is only slightly larger. Compared to small conventional water-tube boilers of modern design or present-day package-type fire-tube units, the generator will produce 3 to 4 times as much steam per cubic foot of space occupied.

The feature that distinguishes this generator from all other types of small steam generators is the use of the controlled re-circulation principle.

Compared to small water-tube boilers, this generator will produce 3 to 4 times as much steam per cu ft of space occupied.

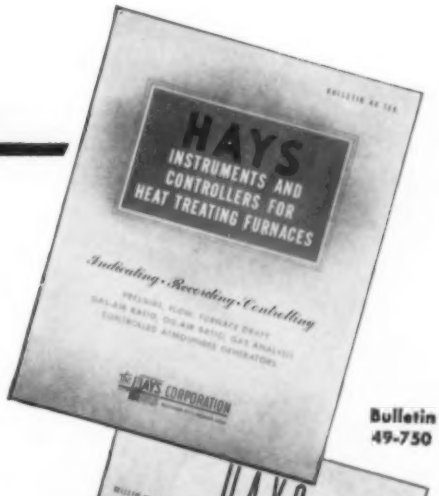


Bulletins on instruments and control for 2 types of furnaces

HEAT TREATING FURNACES

A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages, and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.



Bulletin 49-750

BOILER FURNACES

This bulletin summarizes applications of Hays centralized combustion control to chain grate, underfeed, spreader type, or lever type stokers; to attritia type, bowl type or ball bearing type pulverizers; to a wide range of oil burners including the rotary cup; and to a wide range of gas burners.

The Hays complete line of draft gages, flow gages, and meters (for high and low pressure gases and liquids), portable gas analyzers, automatic CO_2 recorders, and electronic type O_2 recorders are covered.

Bulletin 49-605

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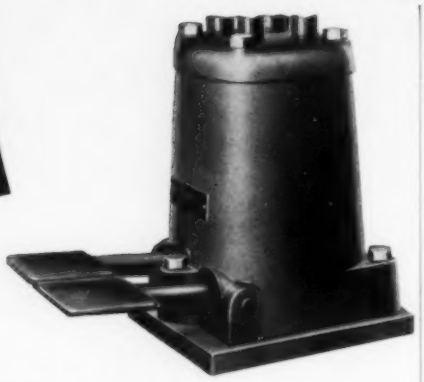
MICHIGAN CITY 13, INDIANA

combustion and industrial instruments and control

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves



No. 3401-R-4
½ Inch 4-Way
Foot Valve

FOOT OPERATED Air Valves

Increase output of hammers, shears, presses, etc.

● Operators have both hands free to handle the work—speeding production. Valving mechanism has stainless steel body and push-pull rods, brass sleeves, self-sealing U-packers and many other refinements, all fully enclosed against dirt, assuring long efficient trouble-free operation. Convenient pipe connections. No metal to metal seating. ⅜″ to 1″ sizes, 3-way and 4-way, neutral position and regular actions. *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1987 East Pershing St., Salem, Ohio

The high rate of heat transfer made possible by the use of this principle permits maximum steam production per unit of heating surface and thus makes possible maximum steam output per unit of space and weight. Moreover, controlled re-circulation assures positive circulation throughout all heating surfaces, virtually eliminates scale formation and permits higher operating efficiency.

INSPECTION TABLE HAS MANY USES

▲ Riverside Metal Co., Riverside, N. J., has designed an inspection table which cuts by 25 per cent the time required to inspect its phosphor bronze, nickel silver, cupro-nickel and beryllium copper alloys. Although designed specifically for inspecting coils of strip metal, the table arrangement can be modified to serve textile, rubber, linoleum, roofing paper and other fields in which material must be unrolled for inspection.

Formerly, to inspect coil strip, small coils were unwound; inspected on one side; turned over; inspected on

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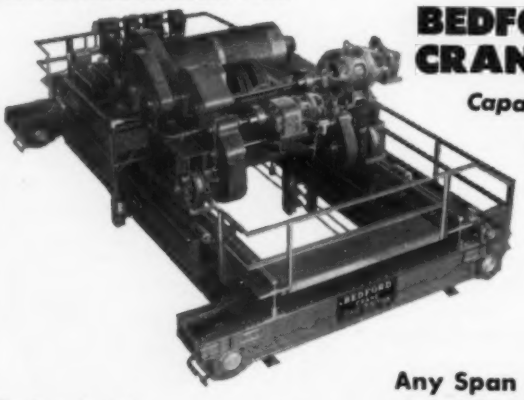

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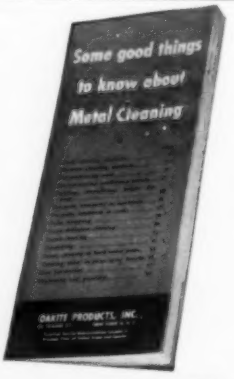
Gray Iron Castings

Which job would you like to improve?



Listed below are some jobs discussed in Oakite's new 44-page illustrated booklet on Metal Cleaning. Let us help you do them with better results, greater economy.

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Tell me (without obligation on my part) about Oakite methods and materials for the following jobs:

- ☐ Tank cleaning
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- ☐ Paint stripping
- ☐ Steam-detergent cleaning
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- ☐ Burnishing
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- ☐ Send me a FREE copy of your booklet "Some good things to know about Metal Cleaning"

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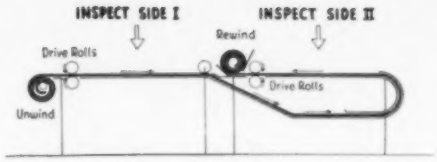
OAKITE SPECIALIZED INDUSTRIAL CLEANING MATERIALS • METHODS • SERVICE



Inspection table cuts inspection time by 25 per cent.

the other side; and rewound. Large coils were unwound; inspected on one side; rewound; then unwound again; inspected on the other side; and rewound. Now, by guiding the strip as shown in the illustration, both sides are inspected in one operation, eliminating both turnover and rewinding. Unnecessary handling operations have been eliminated and inspection time has been cut at least 25 per cent.

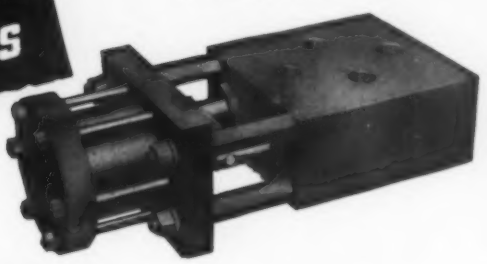
WAX BLENDS USED AS METAL LUBRICANT

▲ S. C. Johnson and Son, Inc., announced the results of production tests which point to a bright future for some waxes as a metal working lubricant.

The tests, conducted in a variety

Quick-As-Wink AIR AND HYDRAULIC Control Valves

¾ Inch 4-Way — 5000 p.s.i. Piloted Hydraulic Valve



PILOT OPERATED Hydraulic Valve

For hydraulic systems to 5000 p.s.i.

● Designed for controlling double acting hydraulic cylinders. The pilot cylinder is controlled by any type of 4-way air valve and is operated either automatically or manually from a convenient control station. Machined steel housing, hard chrome plated ground and polished stainless steel plungers, molded packers sealed by valve pressure. All parts readily accessible without disturbing the piping. ½" to 4" sizes. *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

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Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

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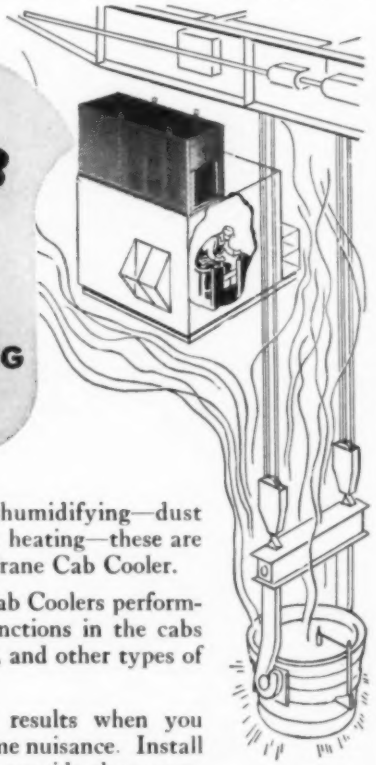
DRAVO CRANE CAB COOLERS

PERFORM EVERY AIR CONDITIONING FUNCTION



Cooling—fume removal—dehumidifying—dust filtering—ventilating—winter heating—these are the functions of the Dravo Crane Cab Cooler.

You will find Dravo Crane Cab Coolers performing these air conditioning functions in the cabs of soaking pit, ladle, stripper, and other types of hot-metal cranes.

And you will observe real results when you eliminate heat fatigue and fume nuisance. Install Dravo Crane Cab Coolers to provide these comfortable working conditions in the cabs of hot-metal cranes.

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No More Frozen or Galled STUDS (even at 1800 F.!) Try this Amazing Money Saver..

FREE Test Sample of the NEW FEL-PRO C-5 "HI-TEMP" THREAD COMPOUND

Eliminates Pitting of Stainless and Alloy Steels at all Temperatures!

CUT costly stud breakage, heater dismantling time, pitting of metal surfaces!

We'd like to send you a free sample of the new Fel-Pro C-5 "Hi-Temp" Thread Compound to try on your toughest thread compound problems, including alloy and stainless steels. Then you can see the amazing, money-saving results being obtained by the nation's largest refineries, utilities and process industries. Fel-Pro's exclusive Colloidal-Copper formula keeps metal parts separated, regardless of temperatures. Its neutral action solves the alloy and stainless steel pitting problems. One utility company reports that heater dismantling time has been cut from two days to four hours, by the use of Fel-Pro C-5 "Hi-Temp". Why not see what "Hi-Temp" can do for you... get your free sample and complete data sheet—*write today!*

FELT PRODUCTS MFG. CO.

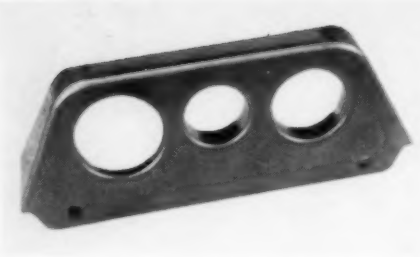
1557 Carroll Avenue, Chicago 7, Illinois

3337

of metal working manufacturing plants, show that special blends of waxes used in place of conventional lubricants permit the drawing of stainless steel far beyond its theoretical capacity. They may also serve as a replacement for the copper flashing on stainless steel wire used for cold heading. Wax blends are also proving useful in the drawing of aluminum. Metal fabricators find that the use of wax as a lubricant extends the life of tools and dies and in some cases completely eliminates degreasing.

A large electrical manufacturing plant using waxes as a drawing lubricant found that blanks of No. 405 stainless steel can be successfully drawn 50 per cent beyond the theoretical capacity of the metal. After a production run of over 2000 pieces, the tool wear was so slight that it could not be determined with standard measuring devices.

The same wax material is successfully being used as a lubricant for various cold heading operations. The wax can be applied to the coil of wire either by dipping it into the wax solution and allowing it to dry or it may be applied just before the wire enters the cold heading machine. When square shoulders are involved in the upsetting operations, they fill in far better when wax is used as a lubricant.



The use of wax will considerably increase die life.

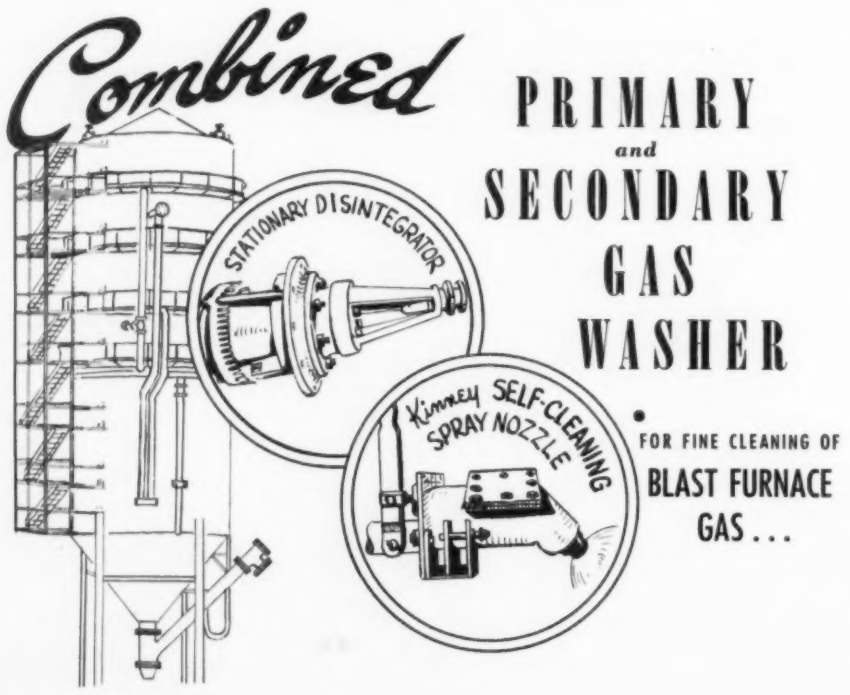
Other cold heading tests on stainless steel wire are being aimed at the elimination of copper flashing normally applied to wire for lubrication. Although incomplete, these tests offer sufficient evidence that the use of wax as a lubricant may make the copper flashing step unnecessary.

Other discoveries were made in collaboration with a large wire manufacturer and a firm making wheel bolts. In the wire mill, extensive experiments were conducted with a specially prepared paste type wax. The wax was used to coat wire in the die box, incorporating aluminum stearates as a coagulant with a small concentration of lime. As a result of this procedure, a dry wax film was applied to the wire which minimized lime flaking and provided a finish that offers considerable resistance to corrosion caused by moisture condensation during storage.

Over 150 tons of this specially finished wire has been upset for automotive wheel bolts and is now being specified by the bolt manufacturer.

Still another use for wax in metal fabricating has been adopted by a screw manufacturer after it was determined the torque of self tapping metal screws could be reduced by 50 per cent if the screws were given a coating of the special wax blend.

The versatility of waxes as lubricants has also become apparent in other metal working operations. For example, a major aircraft company is successfully using wax as a lubricant in the shoe bending of a hard alloy tube. Wax not only reduces the bending pressure from four tons to two and one-half tons, but also materially reduces the loss.



S. P. Kinney Engineers, Carnegie, Pa., design, fabricate and erect combined Primary and Secondary Gas Washers for fine cleaning of blast furnace gas.

This washer can be furnished complete or installed in an existing shell, or the secondary section can be installed after an existing primary washer.

Water requirements are about the same as an ordinary primary washer.

The primary section consists of a bank of Kinney Multiple Port Tile with a bank of Self-Cleaning Spray Nozzles above. The nozzles give a full solid cone spray pattern producing complete and uniform coverage of the tile. If the nozzles should start to plug, they may be cleaned without stopping operations. A pull on the handle at the rear of the nozzle is all that is necessary to clean it. With this nozzle, no piping is used on the inside of the shell and less piping is used on the outside.

The secondary section consists of an inner chamber containing stationary disintegrators. The stationary disintegrator brings the gas into extremely intimate contact with the water. The water passes through a high pressure spray nozzle and forces the gas into a venturi throat which follows. The fine spray from the nozzle completely fills the venturi. After the venturi, the gas and water strike an impingement or deflector cap which further enhances the contact of the gas and water. The particles of dust and dirt are wetted by the high pressure water, and wetted further when they strike the deflector cap. After striking the deflector cap, the dust and water drop out and the gas goes on through the washer.

This intimate contact of water and gas provides a stationary gas cleaning unit which will operate continuously and effectively for fine cleaning of blast furnace gas to 0.025 grains per cubic foot or lower if required.

After the disintegrator chamber, the gas enters an eliminator section. This section consists of a bank of tile covered by Kinney Self-Cleaning Spray Nozzles arranged for intermittent operation.

When the gas leaves the washer it is clean and dry, and ready for use in fine checker hot blast stoves. The gas may be burned in stoves with small flues without causing the flues to clog.

Gas from this washer has been used with success on sets of small checker stoves in one case for ten years, and another set for six years, without requiring any stove or gas main cleaning.

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Book Reviews

▲ **The American Standard Safety Code for Open-Surface Tanks, Z9.1-1951,** a new American Standard Safety Code has just been approved and published by the American Standards Association.

Operations involving the immersion of materials in liquids and their subsequent removal are covered in this code. These include electroplating, washing, anodizing, pickling, quenching, dyeing, dipping, tanning, dressing, bleaching, degreasing, alkaline cleaning, stripping, rinsing, and digesting. The safety of the operator is the primary concern of this standard.

Work on the American Standard Safety Code for Ventilation and Operation of Open-Surface Tanks, Z9.1-1951, was sponsored by the American Industrial Hygiene Association, the American Society of Heating and Ventilating Engineers, and the National Association of Fan Manufacturers. Copies of the American Standard Safety Code for Ventilation and Operation of Open-Surface Tanks, Z9.1-1951, may be obtained from the American Standards Association, 70 East 45th Street, New York 17, N. Y. at seventy-five cents a copy.

▲ **ASTM Manual on Quality Control of Materials,** sponsored by Committee E-11 on Quality Control of Materials, has been issued and takes the place of the widely used ASTM Manual on Presentation of Data.

The ASTM Manual on Quality Control of Materials (STP No. 15-C), 100 pages, in heavy paper cover, can be procured from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at $1.75 per copy.

▲ **Metalworking Lubricants,** a new book just published by McGraw-Hill, 327 West 41st Street, New York 18, N. Y., price $6.00, provides a comprehensive and practical coverage of all types of fluids and compounds used to facilitate metalworking processes. The nature, selection and application of lubricants and fluids are thoroughly discussed. Those used in forming non-metallic engineering materials, such as plastics, are also analyzed.

The author, E. L. H. Bastian, discusses all important advances made in the field, among them pretreatment processes, modern *rolling oil* developments, atmosphere tempering and stress-relief, and grease rolling stability test apparatus. New lubricants such as molybdenum disulphide, chemically active waxes, water-miscible oils for drawing fine-gage wire, and a variety of synthetic fluids and compounds are all covered in detail.

▲ **NEMA Color Markings for Electrode Identification,** Publication No. EW2-1950, gives identification by color of all arc-welding electrodes for which a standard identification has been established. This standard supersedes Publication No. 45-108. ($0.25).

▲ **"Was de Kranfuhrer von seiner Arbeit wissen muss."** (What the Crane Operator Must Know About His Work), by A. Tolksdorf, 2nd edition; 102 pages, 5½ in. by 8 in., 96 illustrations, Verlag Stahleisen, Dusseldorf, 1950. 5.60 German marks. One of a series of educational instruc-

(*Please turn to page 164*)

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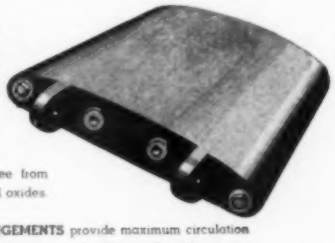

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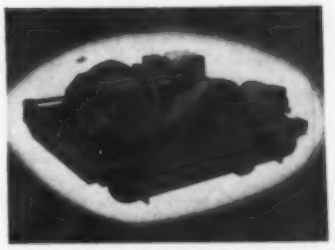

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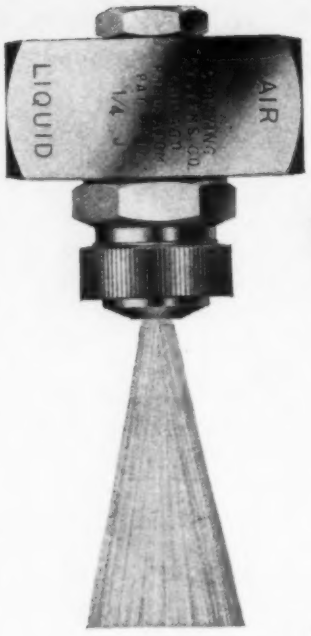

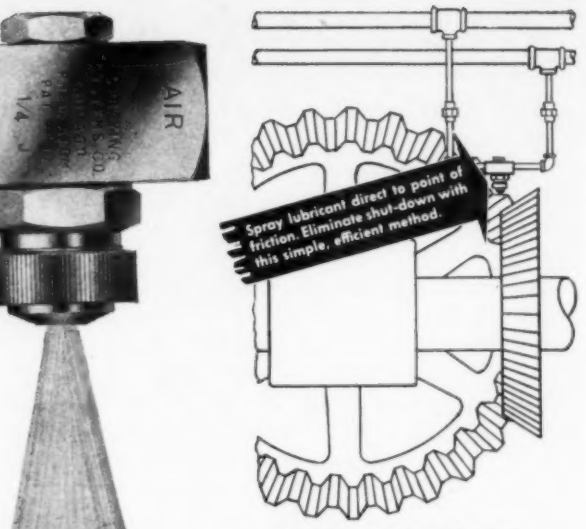

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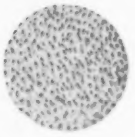

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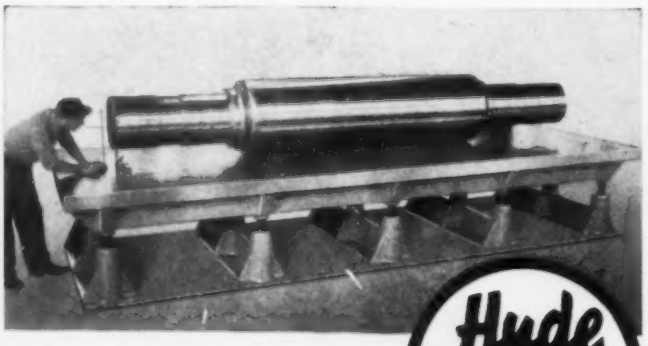

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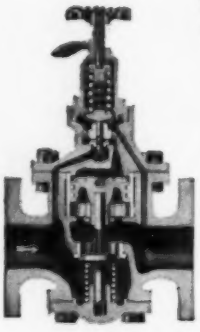

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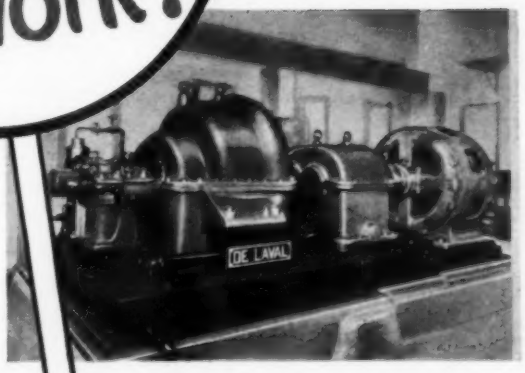

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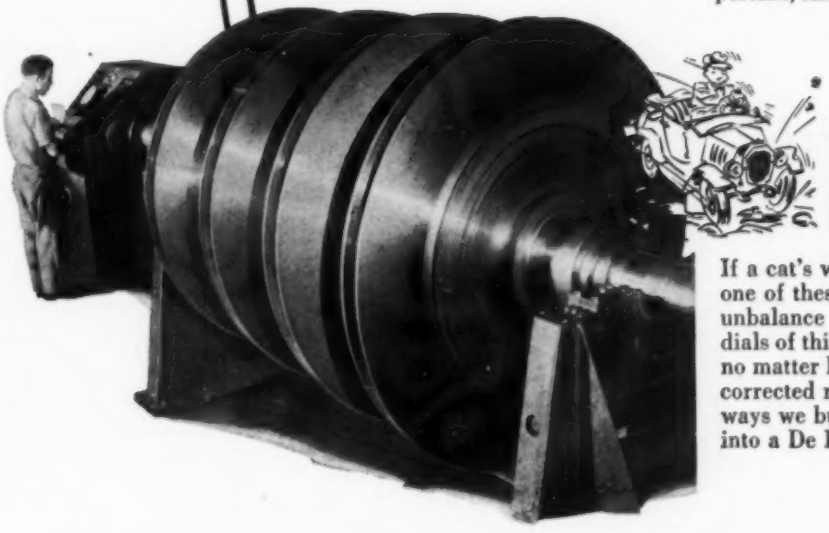
We would never recommend that a centrifugal blower be opened for inspection only once every 22 years. Yet this De Laval two-stage machine in the Houston, Texas Sewage Disposal Plant was recently opened for the first time since it was installed in 1928 . . . *the blower and gear were in near perfect condition!* Our service man only had to clean up the journals a bit and put the unit back in service. If heavy-duty, continuous service is important, take your cue from this. We build 'em to last.



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Book Reviews

(*Continued from page 159*)

tion books for employees in German iron and steel works. The book contains definitions, history of traveling cranes, details of construction, including electrical equipment, instructions for economical and safe operation. It also deals with maintenance, including lubrication. Attention is paid to care of chains and ropes.

Obviously, extremely few crane operators in the U. S. will be able to read this excellent German book. It can be useful as a guide for instructors who write books of this type for the employees in their works. The best use of the book would probably be a translation in which attention is paid to differences between the designs of European cranes and American cranes. (Reviewed by W. Trinks.)

▲ **NEMA Specifying a Mechanical-drive Steam Turbine**, Publication No. TU-3-1950, covers direct-connected or geared mechanical-drive steam turbines. The information deemed necessary in such specifications has been compiled in such form that the purchaser may, if he so desires, use any or all portions as written. ($0.75).

▲ **"Safety in Electric and Gas Welding and Cutting Operations"**—American Standard Z49.1-1950, (42 pages), was prepared by a committee sponsored by the American Welding Society under the procedures of the American Standard Association. It covers regulations for the safe installation and operation of welding equipment for all arc, gas and resistance welding processes.

Copies of this Standard are available at 50 cents each from the American Welding Society, 33 West 39th St., New York 18, N. Y., or American Standards Association, Inc., 70 East 45th St., New York 17, N. Y.

▲ **NEMA Standards for Metallic Rectifiers**, Publication No. MR1-1950, includes basic definitions, ratings, performance and manufacturing standards for copper-oxide rectifier cells and stacks, selenium rectifier cells and stacks, metallic rectifiers used for industrial truck battery chargers, and electroplating metallic rectifier units. ($1.50).

▲ **"Die Eisenerzvorrate der Welt"** (Iron Ore Resources of the World), by G. Einicke is a text volume of 418 pages, 7 in. by 9¾ in. with 192 tables, and an atlas volume containing 100 pages of maps. It is published by Verlag Stahleisen, Dusseldorf 1950, 66 German marks.

A notable work, in which the latest available information in iron ore deposits of our globe, has been compiled by diligent work, continent by continent, country by country. The author reveals the effect of geological formations, iron content of ore, accessibility, cost of transportation, political and economic considerations. The ore beds which are of importance to the German iron and steel industry are given more space than others. (Reviewed by W. Trinks).

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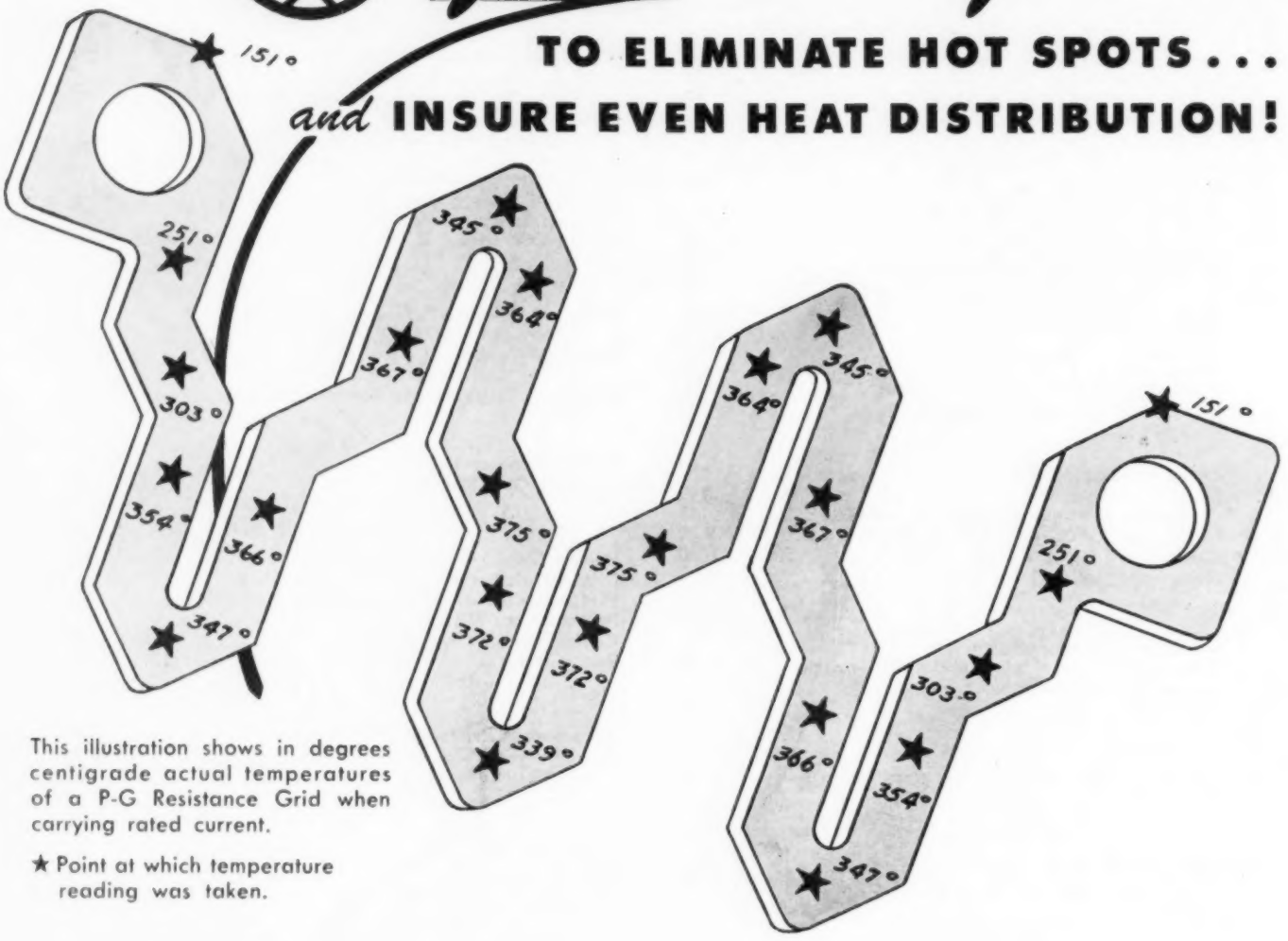

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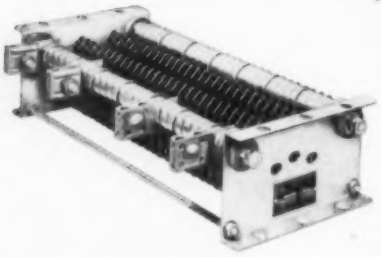

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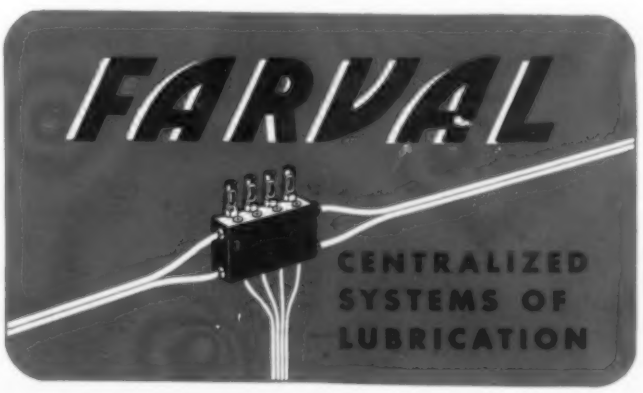

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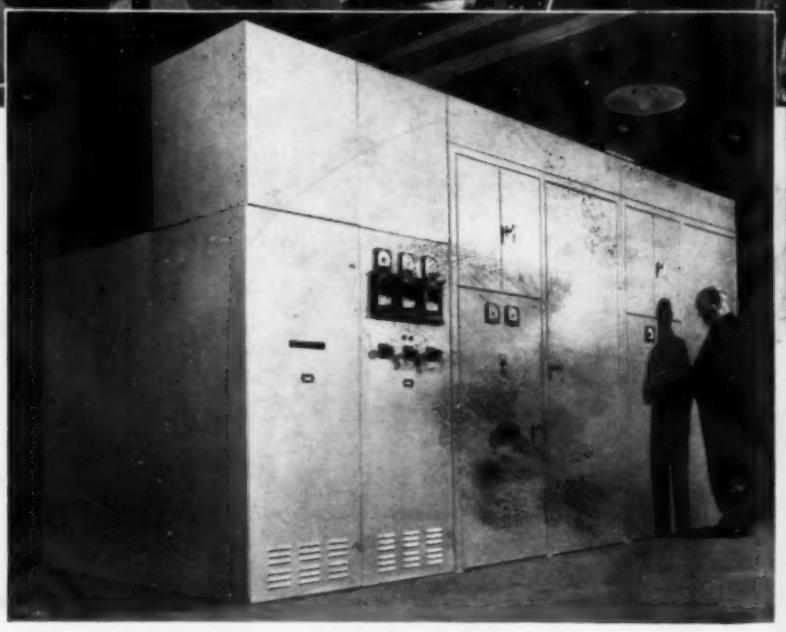

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